



**MICROWAVE ANTENNA TECHNOLOGY
Final Report**

OSU Reflector Antenna Code - User's Manual

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16. Abstract (Limit: 200 words)

The major purpose of this research is to provide a computer-aided analysis and design capability for microwave reflector antenna systems, in the 1-40 GHz range. This capability will allow for the prediction of antenna gain and antenna temperature performance of reflector antennas, under various atmospheric conditions.

The analysis and design capability was accomplished in part by further development of the OSU Reflector Antenna Code. The analysis capability of the Reflector Code was used to guide the design of the seven reflector antennas, of both the focal-point and Cassegrain types. These seven reflector antenna designs were fabricated and tested. The measured data obtained from these tests were used to validate the Reflector Antenna Code. The use of the Reflector Antenna code is documented in Volume III of this final report.

This report documents the seven reflector antenna designs which were fabricated and measured to demonstrate and test the computer-aided analysis and design capability. Selected pattern and gain data calculated by the Reflector Antenna Code and the validating measured data are given. A more comprehensive set of measured data for the seven reflector antenna designs is presented in Volume II of this final report.

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1. INTRODUCTION

The OSU Reflector Antenna Code is an updated version of the NEC Reflector Antenna Code [1,2]. The NEC Reflector Antenna Code has the capability for both near-field and far-field computations for reflector antennas with paraboloidal surfaces. A key feature of the code is its capability for a general reflector rim shape. Many new capabilities have been added in this updated version of the OSU Reflector Antenna Code. This report documents all the capabilities and describes the operation of the updated version of the Reflector Antenna Code.

The theoretical approach for computing the fields of the reflector antenna is based on a combination of Geometrical Theory of Diffraction (GTD) and Aperture Integration (AI) techniques. Typically, AI, also known as the Aperture Field Method, is used to compute the main beam and near sidelobes; GTD is used to compute the wide-angle sidelobes and backlobes. For near field calculations, GTD is sometimes used for the whole region including the near axis region if the near field points are close to the aperture. The GTD and AI approaches used for the reflector code have a basic limitation on the minimum-size reflector that can be modeled. By comparison to the exact solution for a circular disk the code has been shown to be reasonably accurate for reflector diameters as small as 3 wavelengths [3]. There is no limitation on the maximum size of the reflector for the basic analysis. Two efficient techniques have been employed to carry out the aperture integration which is performed over the portion of the aperture plane inside the reflector rim. One is the large subaperture method; the other is the rotating grid method. The subapertures can be electrically large, thus minimizing the computer storage and also the amount of numerical integration required. The major feature of the rotating grid method is that the y-integrations are carried out for each column of the aperture and each one-dimensional integration result is stored. The stored values for the y-integrations are then used for each pattern angle in the plane perpendicular to the y-axis, thus the efficiency approaches that of a one-dimensional integration. Computational advantages on the order of 10 to 100 in computer time ratios are frequently encountered because of the rotating grid feature.

Two GTD approaches have been applied to analyze the wide-angle sidelobes and near field patterns for reflector antennas. The first method is called "segmented-rim GTD" which has been used in the NEC Reflector Antenna Code. The second method is called "multi-point GTD" which is a new technique to calculate the diffracted field. The segmented-rim GTD analysis of the reflector is similar to that of diffraction by a flat plate [4] in that the reflector rim is divided into segments and each segment is treated as an edge of a flat plate which is tangent to the reflector surface. Uniform GTD techniques [5] are used to calculate the edge diffracted field and the slope diffracted field which are the same as those for infinite straight edges. The use of the corner diffraction solution proposed by Burnside et al. [6]

permits the reflector rim to be modeled by piece-wise linear segments. Consequently, reflector rim shapes with corners, such as square or rectangular, can be analyzed by GTD. Smooth rim shapes, such as elliptical or circular, are also modeled by segmenting the reflector rim. Thus, this approach has the added advantage that it eliminates the need for special techniques, such as equivalent line source calculations, for caustic regions near the rear axis as is required by two-point GTD techniques. The limitations of this rim segmentation approach have been investigated for circular rim shapes [3]; and accurate results are achieved if the rim segments are sufficiently small. Typically, 36 rim segments are sufficient to calculate far field patterns for reflector diameters smaller than 22 wavelengths. For reflector diameters of $D=100$ wavelengths and 1000 wavelengths the required number of rim segments is usually about 80 and 240, respectively.

The multi-point GTD method [7] applies numerical techniques to find the diffraction points and caustic distances. For reflector antennas with corners, corner diffracted fields are added to the multi-point GTD. The reflector rim is also divided into many small rim segments, and the geometry associated with these segments such as the unit vectors are calculated and stored. First, the "true corner" is found by checking the angles formed by two adjacent segments. Then the diffraction points are searched around the reflector rim. The diffracted fields from the diffraction points and corners are then calculated and added. The multi-point GTD method greatly improves the computation time compared to the segmented rim GTD since the latter method includes the contributions from all the rim segments while the multi-point GTD only includes the contributions from true diffraction points and corners. The disadvantage of the multi-point GTD method is that it can not be used when the field point is near or at the caustic of the reflector, because a very large number of diffraction points can be found. In this case, the multi-point GTD method must be supplemented by the segmented-rim GTD method.

The conventional aperture integration (AIC) method used in the NEC Reflector Antenna Code approximates the aperture fields by the geometrical optics (G.O.) fields, i.e., the reflected fields from the reflector surface. Thus, the integration is performed only over the projected aperture of the reflector. The G.O. approximation is good enough for most cases. However, when the effect of the diffracted field contribution to the aperture fields become significant, the G.O. field approximation is no longer adequate. An extended aperture integration (AIE) method has been developed and included in the latest version of the Reflector Antenna Code to correct the inadequacy of the G.O. approximation of aperture fields. In the AIE method, the aperture is extended to include the diffracted fields outside the original projected G.O. aperture. This method improves the results of aperture integration especially in the wider sidelobe regions. However, without the multi-point GTD, the AIE method will not be as efficient since excessive

CPU time will be needed to calculate the corrected aperture fields by the method of segmented-rim GTD.

Feed blockage is modeled by the physical optics model of a rectangular or a circular flat plate [8] in the NEC Reflector Antenna Code. These models should be valid in the main beam and near sidelobe region where the feed blockage effect is most significant, because the physical optics model is accurate for forward scattering. However, these feed blockage models have to be inside the G.O. region of the reflector in order to be accurate. Thus, feed scattering effects cannot be modeled this way for an offset reflector. Consequently, the AIE method is used to calculate feed scattering effects for offset reflector antennas.

Strut scattering is modeled by assuming each strut segment scatters in the same way as an infinite cylinder. The strut scattering from each strut segment is then summed to get the total strut scattering. Struts with circular cross sections were considered in the NEC Reflector Antenna Code. General cross section struts have been included in the updated version of the code. Also, two sources of the incident field are used for the strut scattering. One is the geometrical optics fields from the reflector surface (as used in the NEC Code) and the other one is the direct illumination by the feed.

Capabilities for analyzing Cassegrain and Gregorian dual-reflector antennas are also included in the updated Reflector Antenna Code [9]. A two-step procedure is required to calculate the patterns of such reflectors. The subreflector patterns are calculated first by GTD and then used as the feed for the main reflector. Then the patterns of the main reflector which is a paraboloidal surface are calculated.

In the NEC Reflector Antenna Code, the radiation patterns of the feed horn with circular symmetry can only be calculated by aperture integration. Only the main beam and first few sidelobes are provided accurately by this approach. No back lobe information is given. A body of revolution moment method code has been implemented in the new Reflector Antenna Code which can be used to obtain the complete 360° patterns of horns with body of revolution such as conical horns, conical corrugated horns, dual-mode horns, and circular waveguides.

Tolerance effects for the reflector surface can be deterministically analyzed in the OSU Reflector Antenna Code. Surface errors can be input in the code and the scattered field from the surface errors and the total field of the reflector can be calculated.

With multi-beam systems for satellite communications, array feeds and defocussed feeds are increasing in importance. Reflector antennas with array feeds can also be modeled with the code. A ray tracing technique is applied to obtain the aperture fields of the reflector antenna with an arbitrary feed location. The computer code permits the reflector patterns to be calculated by either the principle of

superposition for each feed element or a two-step procedure. The straight-forward two-step procedure first computes the feed pattern of the complete array and then treats this pattern as that from a single feed to compute the reflector pattern either by AI or by GTD. This procedure is valid provided the array has a well defined phase center at ranges corresponding to the distance from the feed to the surface of the reflector. When appropriate, the two-step procedure is more efficient. Some capabilities of the original NEC Reflector Antenna Code are summarized as follows:

1. A general reflector rim shape may be used (piecewise linear). Irregular or jagged shapes may not work because of complicated shadowing of the spillover fields and complicated limits for the AI.
2. The required input data for the feed pattern is minimized by piecewise linear pattern fitting. The feed may be linearly polarized with any orientation or circularly polarized.
3. A feed pattern option is available for a dominant mode horn feed (either corrugated or smooth) in which the horn dimensions are input.
4. Storage and computation time of aperture data for AI is minimized by using a principal rectangular grid and interpolation of the aperture field.
5. The combined AI/GTD approach gives full pattern capability for both far field and near field data.
6. The efficiency of field computations is maximized by the use of GTD for wide pattern angles and the use of the rotating grid method for far field computations at small angles (main beam region).
7. Feed blockage is simulated by a physical optics model of a rectangular or a circular disk.
8. Scattering from feed struts with circular cross section and piecewise linear axes can be modeled.
9. The capability is provided to directly input a linearly polarized aperture field. No feed pattern is then required.

The GTD and AI approaches used for the code have a basic limitation on the minimum size reflector that can be modeled. This limitation is one the order of 3 to 5 wavelengths for the reflector diameter. By comparison to the exact solution for a circular disk the code has been shown to be reasonably accurate for reflector diameters as small as 3 wavelengths [3]. There is no basic limitation on the maximum size of the reflector for the basic analysis. (In the code, the reflector

antenna must have sufficiently good tolerances, especially at high frequencies, so that it can be accurately modeled by the code.)

Some new capabilities of the updated OSU Reflector Antenna Code are summarized as follows:

1. A multi-point GTD method is used to improve the calculation efficiency on the wide angle sidelobes of the reflector.
2. An extended aperture integration (AIE) is implemented to improve the accuracy of aperture integration for offset reflector antennas.
3. The radiation patterns of Cassegrain and Gregorian dual-reflector antennas can be calculated.
4. Complete patterns of horn antennas with circularly symmetric geometry can be calculated.
5. The patterns of reflector antennas with array feeds or defocussed feeds can be calculated.
6. Feed scattering effects can be calculated for offset reflectors by the Extended Aperture Integration method.
7. Struts with general cross section can be modeled.
8. Direct feed incidence on the struts is included.
9. Surface tolerance effects on the reflector patterns can be modeled.

The practical limitations on this version of the code can be summarized as follows:

1. The grid size used for aperture integration must be chosen sufficiently small to give a good representation of the aperture field distribution.
2. Array variables associated with the rim data, the principal grid, the feed pattern and the output pattern must be given sufficient dimensions for the required input data. Similar restrictions apply to the dimensions of struts and plates.
3. The strut diameters should be no more than 10 wavelengths.

The use of the OSU Reflector Antenna Code is described in this report. Examples are included at appropriate places so that the user can learn how to run the code.

2. OUTPUT FROM THE CODE

For far field calculations or for near field calculations with constant range (LRANG=true), the total field is converted to principal and cross polarized components as referred to the polarization of the field components from a Huygen's source, definition 3 of Ludwig [10]. For near field calculations with constant-Z plane (LRANG=false), the field is expressed in rectangular components.

2.1. Magnitude and Phase Outputs

Far field calculations can be made with or without the range factor and this is controlled by the input logical variable LRFCT. If the range factor is suppressed (LRFCT=false) the magnitude and phase outputs express the antenna field pattern. For far field calculations including the range factor (LRFCT=true) or for near field calculations, the magnitude and phase outputs are expressed as the electric field relative to the aperture field level.

2.2. dB Output

The dB output of the code is expressed as antenna directive gain relative to isotropic when feed patterns are input with the FD:Command. When aperture fields are directly input by the AP:Command, the dB output simply gives the relative electric field levels.

In order to determine the antenna gain levels the radiated power is determined by integrating the power density radiated by the feed. Thus

$$P_{\text{rad}} = \iiint \frac{|E_f|^2}{Z_0} R^2 \sin\theta \, d\theta \, d\phi \quad (1)$$

where the field of the feed is given by

$$E_f = \frac{F}{R} g_f(\psi, \phi) e^{-jkR} \quad (2)$$

and F is the focal length of the reflector. This gives

$$P_{\text{rad}} = \frac{F^2}{Z_0} P_{\text{RAD}} \quad (3)$$

where $Z_0 = 376.7$ ohms and

$$P_{\text{RAD}} = \iiint |g_f|^2 \sin\theta \, d\theta \, d\phi \quad (4)$$

is calculated in the code. Consequently, the absolute field level is given by

$$|E| = |E_0| \left(\frac{P_t}{P_{rad}} \right)^{1/2} \quad (5)$$

where E_0 is the magnitude output of the code (relative electric field) and P_t is the actual radiated transmitter power (in Watts). The actual power density (in Watts per square meter) is given by

$$S_p = \frac{|E|^2}{Z_0} = \frac{|E_0|^2}{Z_0} \frac{P_t}{P_{rad}} = \frac{|E_0|^2 P_t}{F^2 P_{RAD}} \quad (6)$$

The antenna gain G can be determined from the power density as follows:

$$S_p = \frac{P_t G}{4\pi R^2} \quad (7)$$

where R is the range as referred to the reference point X_{ref} . In the code the reference point is chosen on the aperture plane, thus

$$X_{ref} = (X_0, Y_0, ZOP)$$

where X_0 and Y_0 are at the center of the aperture,

$$ZOP = \frac{(R_{max})^2}{4F}$$

and R_{max} is the maximum radius to the reflector rim. The antenna gain can be determined from the magnitude output of the code as follows:

$$G = \frac{4\pi R^2 |E_0|^2}{F^2 P_{RAD}} \quad (8)$$

The information for F and P_{RAD} are included in the variable

$$REFDB = 10 \log \frac{4\pi \lambda^2}{F^2 P_{RAD}}$$

which is used in the DBPHS subroutine to calculate far field gain and is given as output from the code. For far field calculations including the range factor (LRFCT=true) or for near field calculations, the near field gain is calculated from Equation (8) by using the DBPHS subroutine with

$$\text{REFNF} = 10 \log \frac{4\pi \lambda^2}{F^2 P_{\text{RAD}}}$$

For radiation hazard applications the HZ: Command is used to calculate the power density in milliwatts per square centimeter, total electric field in Volts per meter and near field gain in dB. The power density is based on the electric field and free space impedance.

3. APPLICATIONS OF THE CODE

The reflector code can be used for the following basic applications:

1. Pattern prediction of existing reflector antennas.
2. Reflector antenna design.
3. Radiation hazard calculations.
4. EMC or coupling calculations with small antennas.

The far field capability of the code is used for applications 1 and 2 listed above. For pattern prediction it is necessary to have sufficient information about the reflector dimensions and feed pattern. For antenna design the code can be used in an iterative manner to seek a practical design having a given pattern performance goal. Or, the code can be used to give a more accurate prediction of the performance of a design obtained from more approximate techniques.

The near field capability of the code can be used for EMC and radiation hazard applications. The code can accurately calculate the field at virtually any point that is at least one diameter from the reflector. Since the code is efficient even for near field computations it eliminates the necessity to rely on approximate techniques as has usually been done in the past.

For radiation hazard applications the code is used to calculate the level of the electric field and the power density at the near field point as discussed in Section II.

For EMC or coupling calculations, the coupling can be calculated by using the CL: Command. The output of the code will then give the ratio of the received power to transmitted power between the reflector and the linear antenna in dB. The coupling output data which result from use of the CL: Command are calculated from the reaction integral involving the fields of the reflector and the currents of the linear antenna.

4. COMMAND WORD SYSTEM

The method used to input data into the computer code is based on a command word system. With this system the code stores the previous input data such that one need only input that data which needs to be changed from the previous execution. This is especially convenient when more than one problem is to be analyzed during a computer run. Also, there is a default list of data built into the NX: Command which is automatically executed before any other command. Thus the code will run the default case by simply executing the XQ: Command.

It is recommended to not execute any command for which input data is not needed. For example, the NF: Command usually is not needed for far field data.

All angles in these commands are input in degrees. For distance or length variables, the units of length are specified according to the value of IUNIT in the DG: Command, unless otherwise noted. Consequently, the DG: Command should be executed before any other command in which the input units need to be specified. However, the CM: or CE: Command can be executed before the DG: Command because it does not require input units. If the DG: Command is not used, the unit of length is inches.

NOTE: THE DG: COMMAND SHOULD NORMALLY BE THE FIRST COMMAND (AFTER CM: OR CE:) IN A DATA FILE!

The following sections define in detail each command word and the variables associated with them. A block diagram is given for each command word which shows the way to input the data associated with that command.

Command CM: or CE: COMMENTS ON OUTPUT DATA

This command enables the user to write comments along with the output data of the code. If the CM: command is input, comment cards can then be read and the corresponding comments will be written as part of the code output. Each comment card except the last in a sequence must have 'CM:' for its first three characters. The last comment card in the sequence must have 'CE:' for its first three characters: then the code returns for another possible command word.

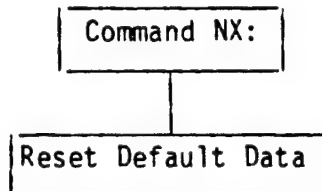
1. READ: IR(I),I=1,24

- a) IR(I): This is a dimensioned array of up to 72 typed characters (assuming 3 characters per word) which compose the desired comment. As stated before, the first three characters must be 'CM:' for all comment cards except 'CE:' for the last comment card in the sequence.

Command NX: DEFAULT INPUT DATA

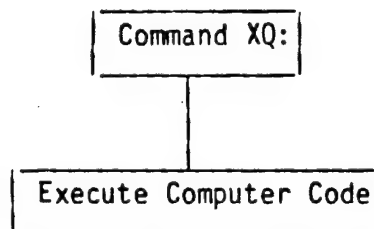
This command resets the input data of the code to that of the default case. Thus the user can read this command word followed by the XQ: Command to run the default data at any time. Also, this command is automatically executed before any other command. Thus the default case can be run as the first case by a single XQ: Command word.

BLOCK DIAGRAM FOR DEFAULT DATA



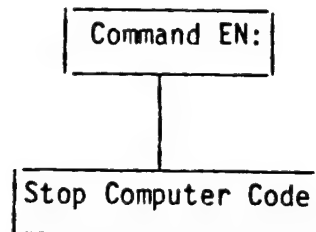
Command XQ: EXECUTE CODE

This command is used to execute the reflector code so that the fields of the reflector may be computed and output. After execution the code returns for another possible command word.



Command EN: STOP CODE

This command stops execution of the code.



Command DG: REFLECTOR (DISH) GEOMETRY

This command enables the user to specify the reflector type and its geometry, that is, the shape and dimensions of the reflector. The rectangular grid used for aperture integration or physical optics integration is also specified by this command.

All units are specified according to the value of IUNIT. Since all units are specified according to the value of IUNIT in this command, this command should be executed before any other command in which the input units need to be specified. The CM: or CE: command can be executed before the DG: command because it does not require input units.

NOTE: THE DG: COMMAND SHOULD NORMALLY BE THE FIRST COMMAND IN A DATA FILE!

1. READ: NTYPE

- a) NTYPE: This integer variable specifies the type of reflector surface as follows

NTYPE = 1: parabolic reflector surface
 10: hyperbolic reflector surface
 11: elliptic reflector surface

For NTYPE > 10, LAIC (in TO: Command) must be false.

2. READ: IUNIT,F,GRIDX,GRIDY,D,NRIM

- a) IUNIT: This integer variable indicates the units for the input data as follows:

IUNIT = < 1-> meters
 2-> feet
 3-> inches

- b) F: This real variable defines the focal distance of the reflector as shown in Figure 1.

- c) GRIDX, GRIDY: These real variables define the rectangular grid dimensions, GRIDX and GRIDY, as shown in Figure 2b. The rectangular grid is used for aperture integration or surface current integration (physical optics) and thus its size must be sufficiently small to provide a reasonable representation of the aperture field or surface current. However, the grid dimensions may be large in wavelengths for aperture integration. The grid dimensions GRIDX and GRIDY together with the reflector size (aperture size for aperture integration) control the number of grid lines MMAX, NMAX used for integration. The maximum number of grid lines is limited by MDGRID. At least 3 grid lines must be used in the code. Presently, $3 < \text{MMAX} < 200$, $3 < \text{NMAX} < 200$.

Note that more grid lines are required when the rotating grid is used for off-principal plane cuts. Approximately 50% more grid lines are required for PHI-cuts near 45° and odd multiples of 45° .

- d) D: This real variable defines the diameter of the reflector. If the diameter is read as a positive value ($D > 0$), the reflector is assumed to be circular as shown in Figure 1 and the code generates the rim points. If the diameter is zero, a general rim shape may be read. If the diameter is -1, an elliptic rim is assumed and the lengths of the major and minor axes of the ellipse are read.
- e) NRIM: This integer variable defines the number of input rim points. For circular rims ($D > 0$), read $\text{NRIM} = 0$ for automatic calculation of NRIM in the code. Presently $3 < \text{NRIM} < 627$.

3. READ: FC2

This statement is skipped if $\text{NTYPE} < 10$

- a) FC2: This real variable specifies the distance between the focii of hyperbolic and elliptic reflectors as shown in Figure 1.

4. READ: DAA,DBB

This statement is used for D=-1 only (elliptic rims).
The geometry of the elliptic rim is shown in Figure 3.

- a) DAA: This real variable defines the length of the major axis of the elliptic rim.
- b) DBB: This real variable defines the length of the minor axis of the elliptic rim.

5. READ: ((RIM(NE,N),N=1,2),NE=1,NRIM)

This statement is used for D=0 only (general rim shape).

- a) RIM(NE,N): This doubly dimensioned real variable is used to specify the location of the NE-th corner of the projected piecewise linear aperture rim as shown in Figure 2a. It is input on a single line with the real numbers being the x, y coordinates of the corner which correspond to N=1,2, respectively, in the array.

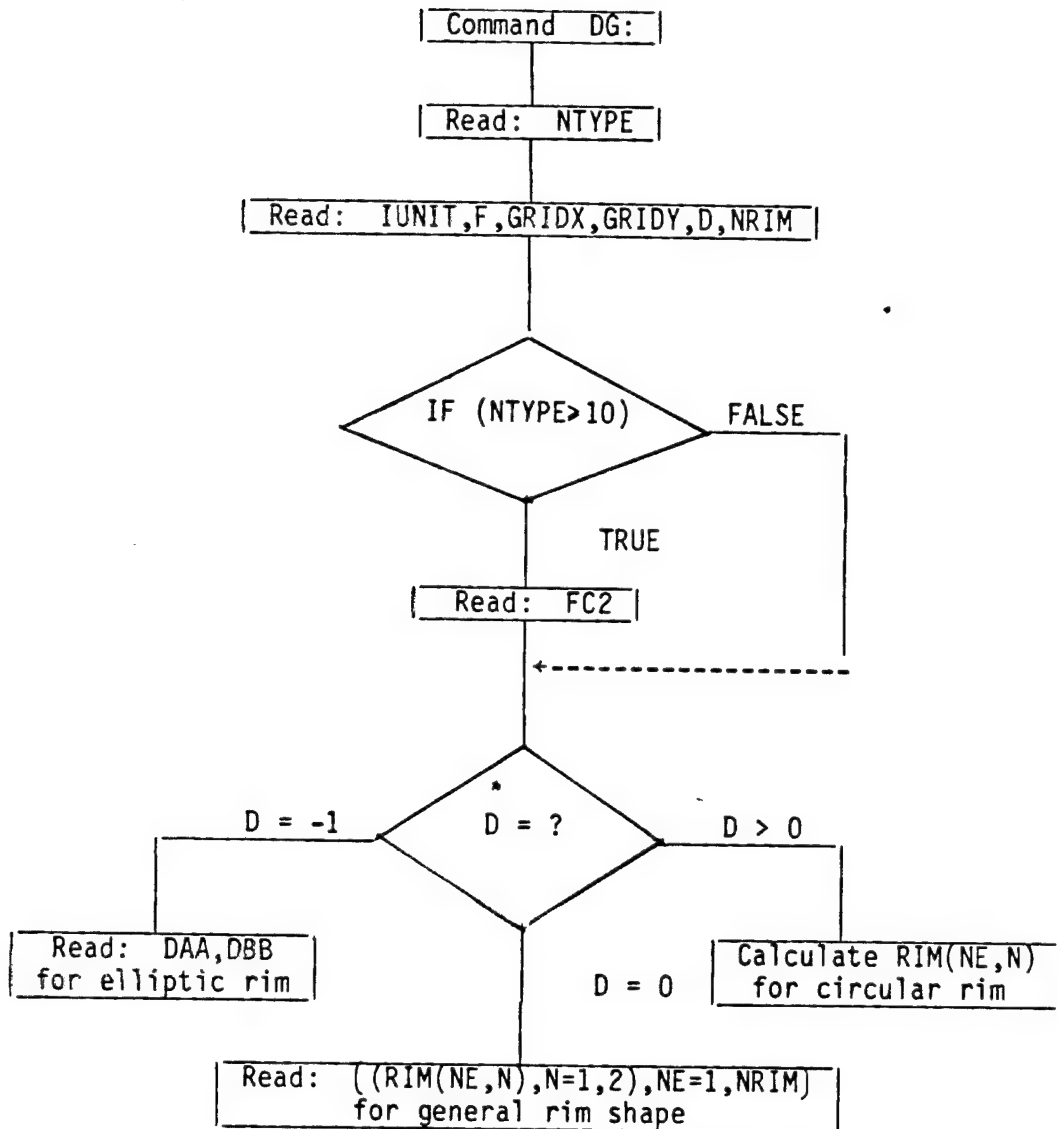
Note: Rim points must be input in the counterclockwise sense.

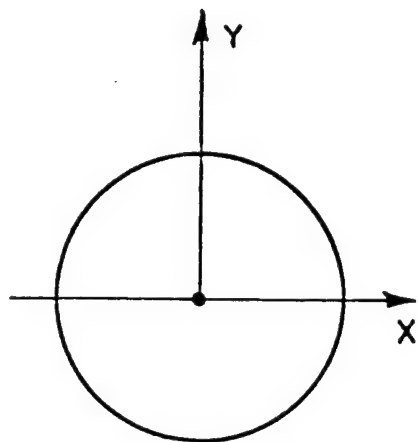
A smooth portion of the reflector rim can be simulated by using a sufficient number of rim points. A recommended criterion for the length (RIML in wavelengths) between two consecutive rim points on the smooth rim portion is as follows:

$$\frac{\text{RIML}}{\lambda} = \min \left(\sqrt{\frac{F}{2\lambda}}, 0.1F/\lambda \right)$$

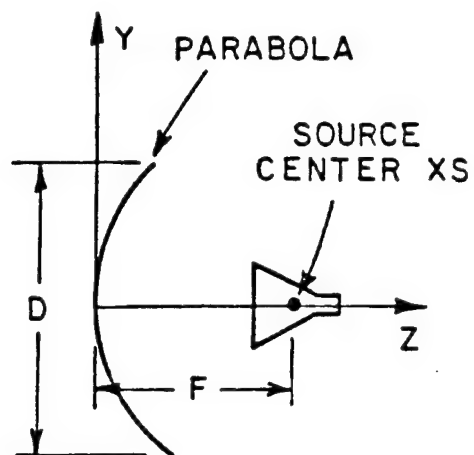
where F is the focal distance in wavelengths in read statement 2.

BLOCK DIAGRAM FOR REFLECTOR GEOMETRY

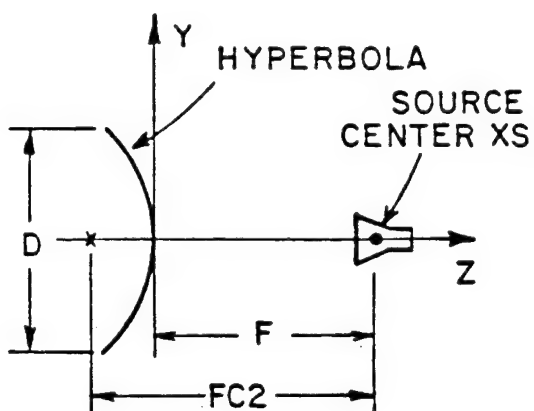




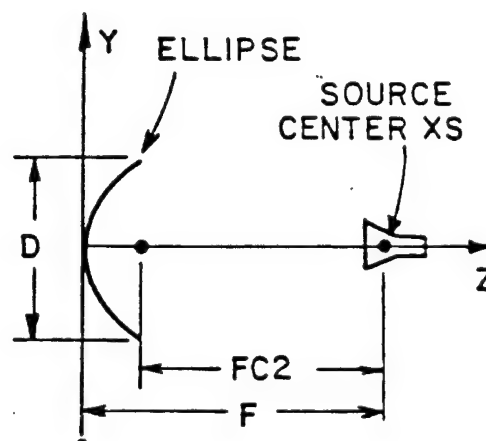
(a) Front view



(b) Side view of parabolic reflector

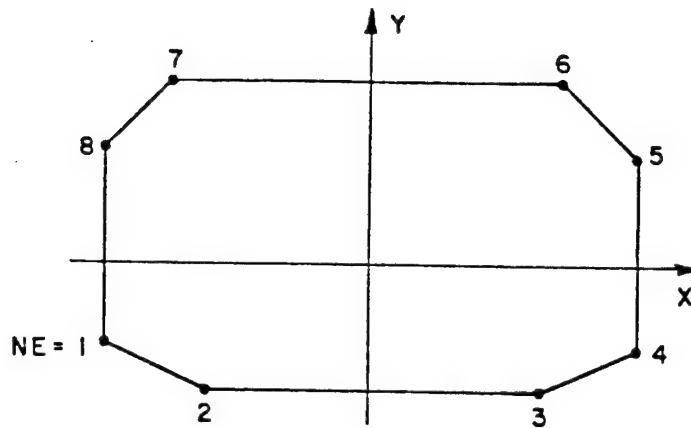


(c) Side view of hyperbolic reflector



(d) Side view of elliptic reflector

Figure 1. Center-fed circular reflector. ($D > 0$)

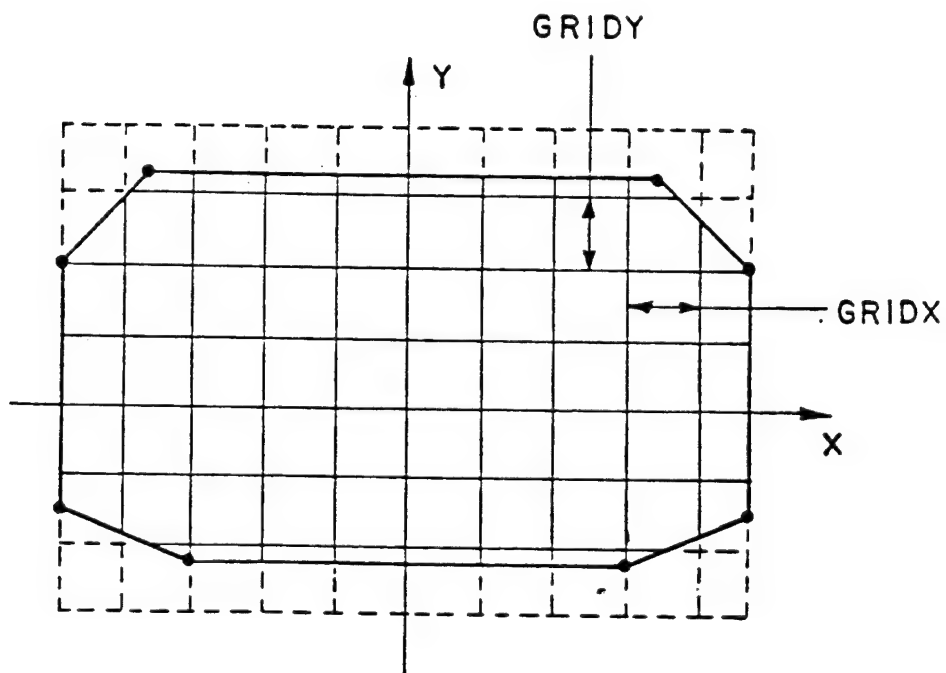


$$\text{RIM}(\text{NE}, 1) = X_{\text{NE}}$$

$$\text{RIM}(\text{NE}, 2) = Y_{\text{NE}}$$

PROJECTED RIM OF REFLECTOR

(a) Non-circular: $D=0$



(b) Principal grid

Figure 2. Reflector rim geometry and principal rectangular grid.

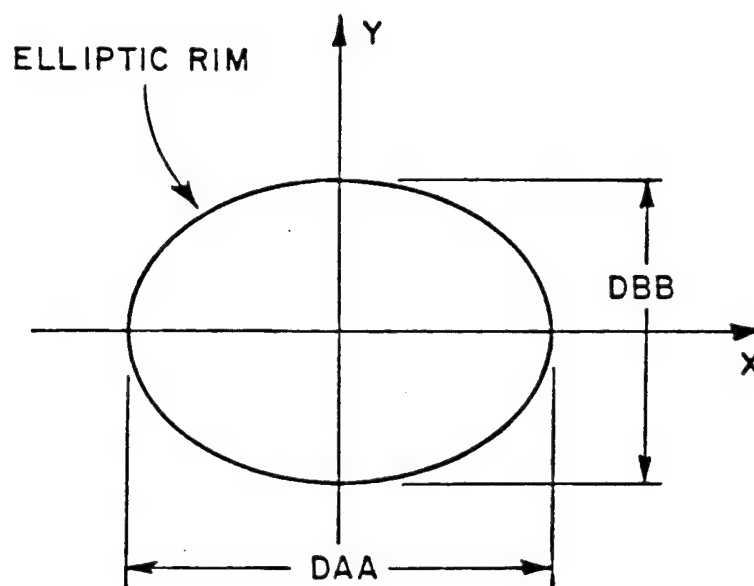


Figure 3. Front view of elliptic rim reflector ($D=-1$).

Examples of a 24.0" parabolic reflector antenna are given in Appendix B to illustrate how the DG: Command in the Reflector Antenna Code is used to obtain reflector antenna patterns. Some often used commands other than the DG: Command are also used in those examples. The first example of this section shows how to obtain the radiation patterns of Cassegrain reflector antennas. Similar processes can be used to calculate patterns of Gregorian reflector antennas. When running the subreflector patterns, one has to set the phase center X00 at the second focus of the subreflector in order to get constant phase in the G.O. region. The phase center X00 is input from the NF: Command and is shown in Figure 4.

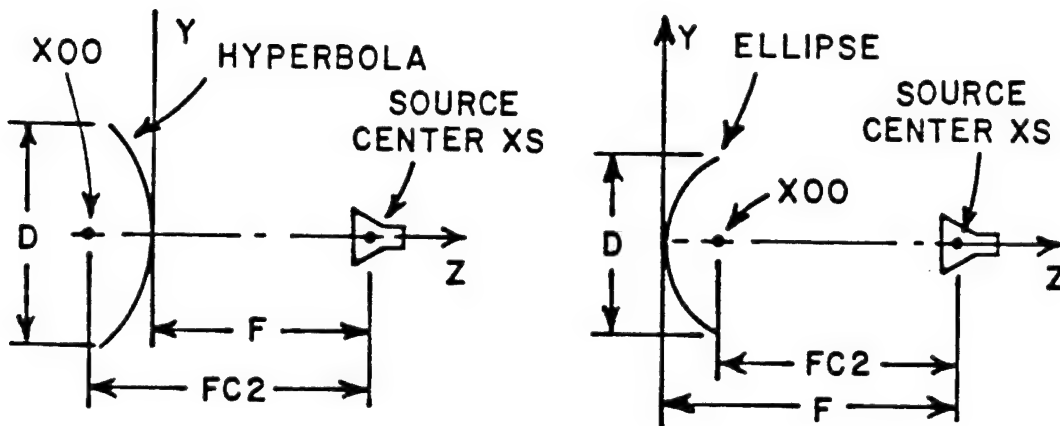


Figure 4. Phase center for subreflector pattern calculation.

The second example shows how to input a reflector with elliptic rim shape by setting $D=-1$.

Example 1:

This example illustrates how to calculate the patterns of a Cassegrain reflector antenna by a two-step procedure from the reflector antenna code. The geometry of the antenna is given in Figure 5 with

$$\begin{array}{ll} D_H = 2.919" & , \quad D_M = 24.0" \\ F = 4.163" & F_C = 4.728" \\ F_M = 8.0" & f = 38.0 \text{ GHz.} \end{array}$$

The primary feed is a circular TE₁₁ mode conical horn with aperture diameter 1.2", flare angle 14.9° and phase center 0.565" behind the aperture. The primary feed is located at the real focal point of the reflector antenna system. The patterns of this conical horn are calculated by the AP: Command and the results are given in the example of the section of the AP: Command.

The subreflector of the Cassegrain antenna is a hyperbolic reflector (NTYPE=10) and its patterns are calculated first. The input data of this run are given in Table 1. Note that the feed data in the FD: Command are obtained from the example in the AP: Command section by setting LFDOUT=T in the PZ: Command. The computed and measured principal patterns are given in Figure 6. The computed subreflector pattern data are stored in Unit #7 by LFDOUT=T in PZ: command for the purpose of the next run.

After the subreflector patterns are obtained, the patterns of the parabolic main reflector (NTYPE=1) can be calculated by using the subreflector patterns as the feed patterns. The input data of this run are given in Table 2. The data in FD: command are obtained from previous run. The calculated and measured patterns of the main reflector are given in Figure 7.

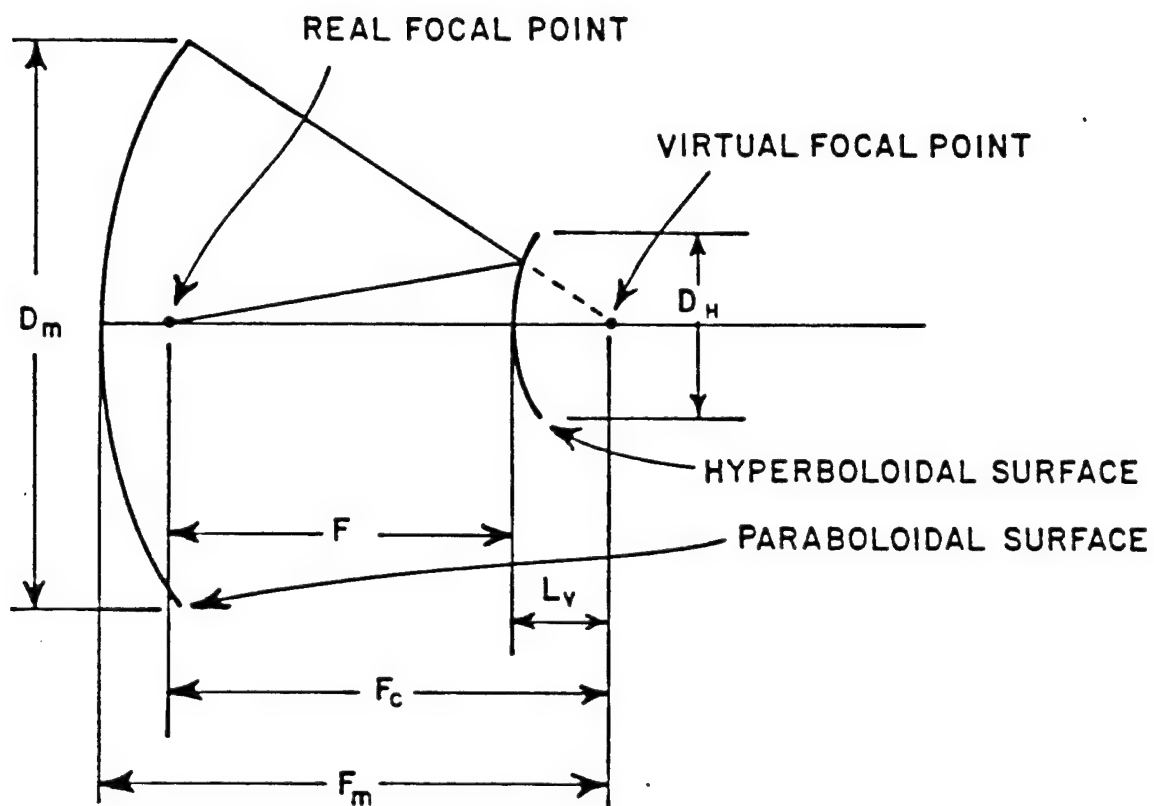


Figure 5. Geometry of Cassegrain reflector antenna.

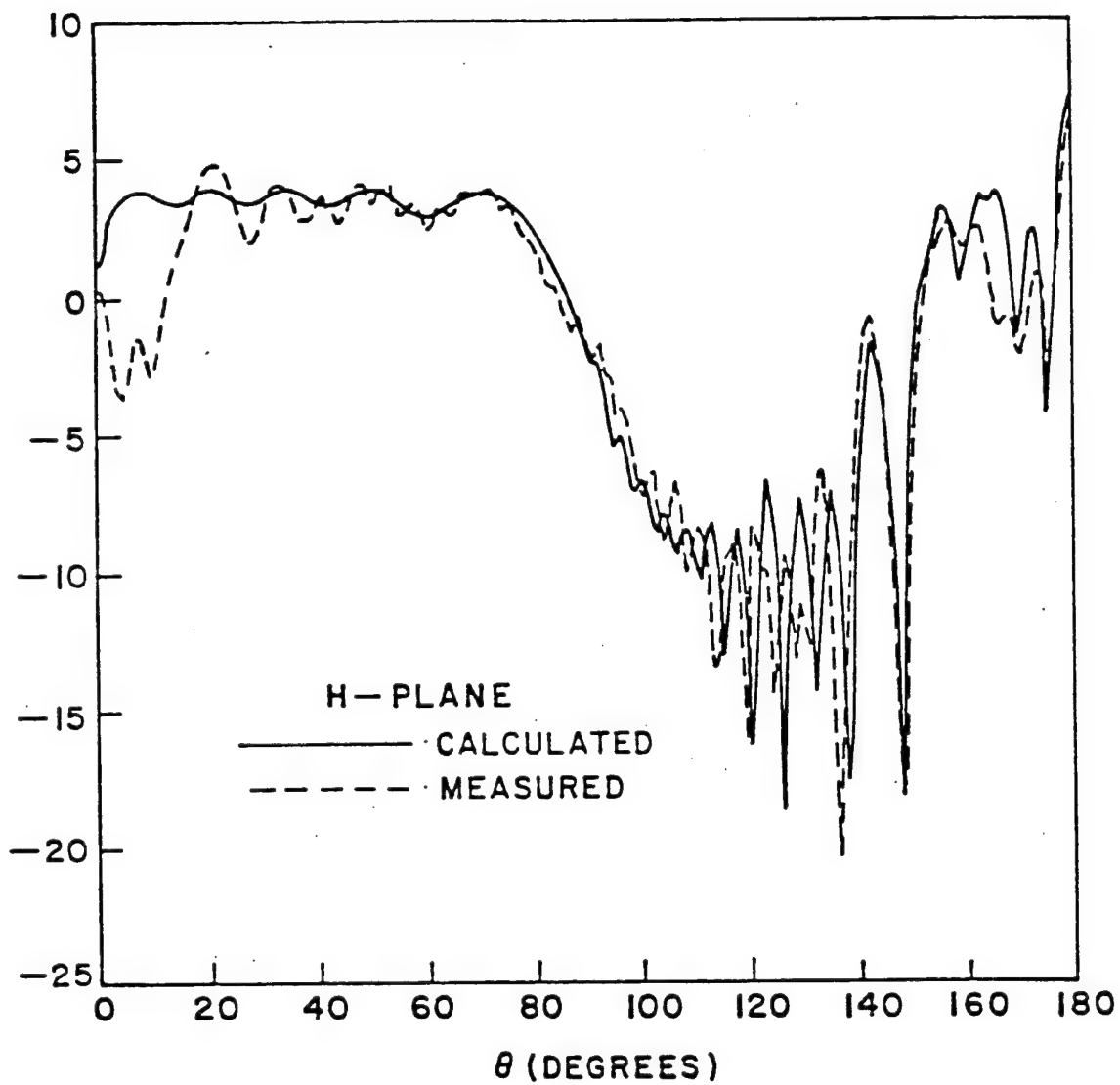


Figure 6. H-plane and E-plane patterns of hyperbolic subreflector of the example.

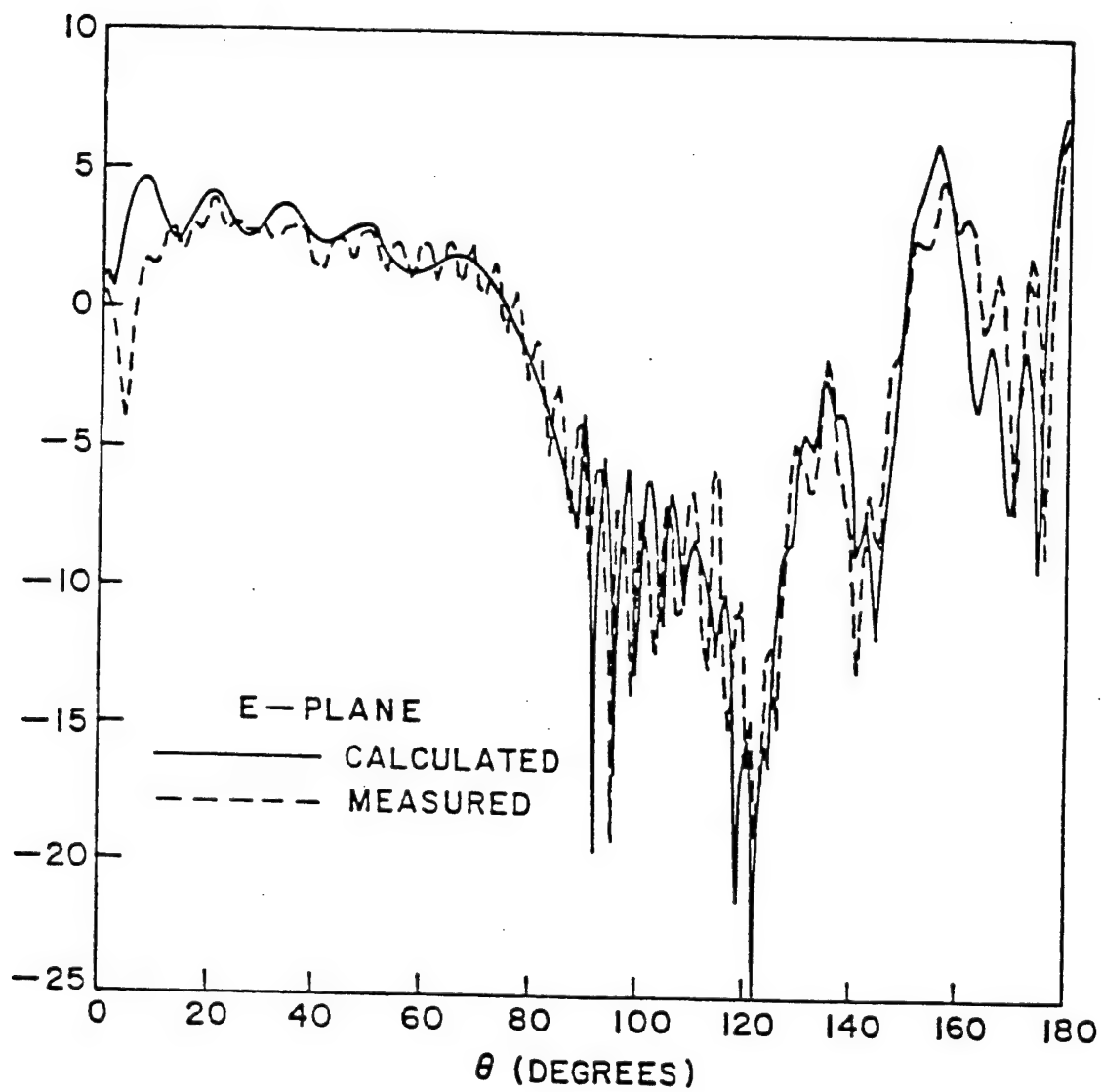


Figure 6. (Continued.)

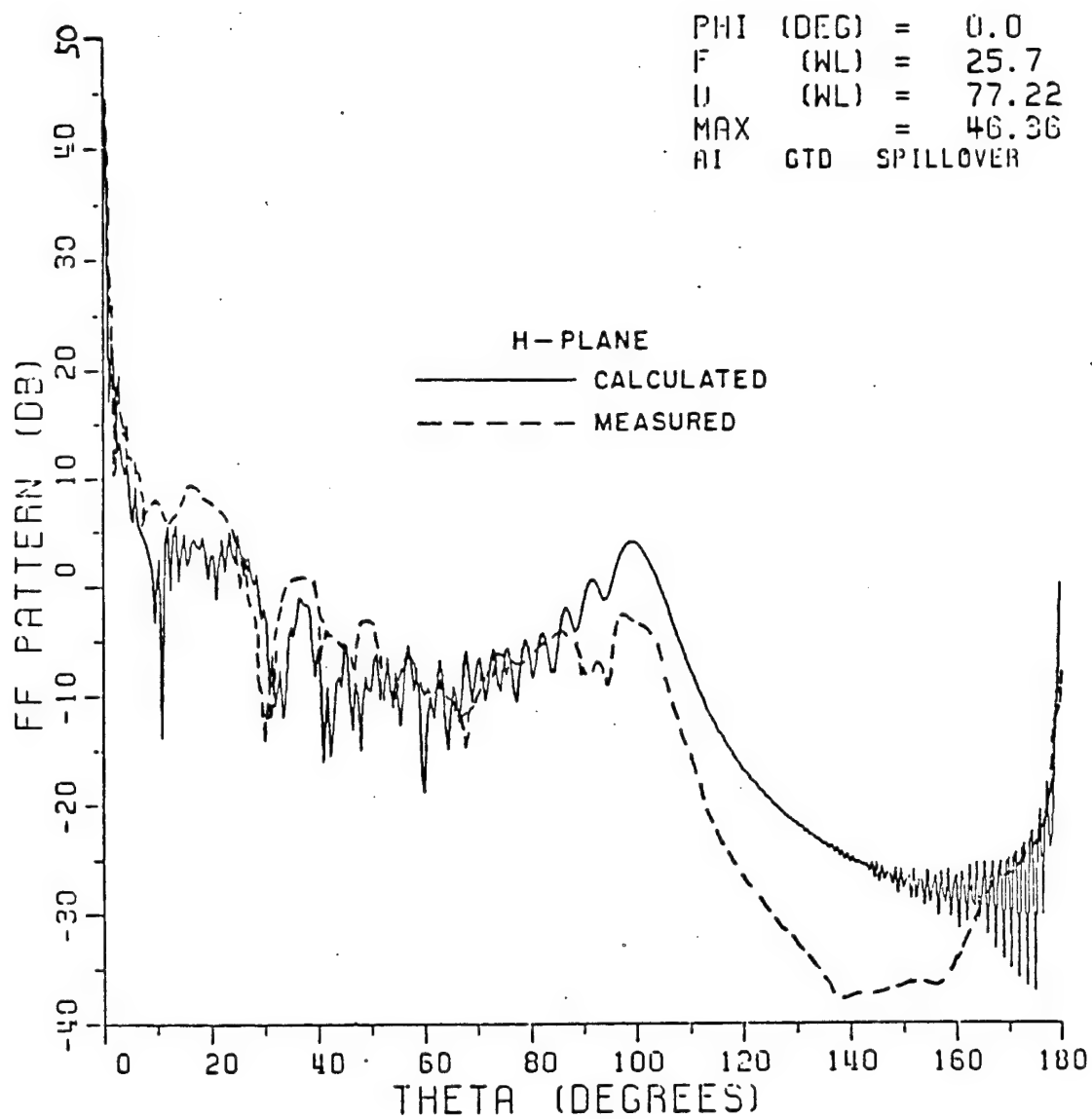


Figure 7. H-plane and E-plane patterns of main reflector of the example.

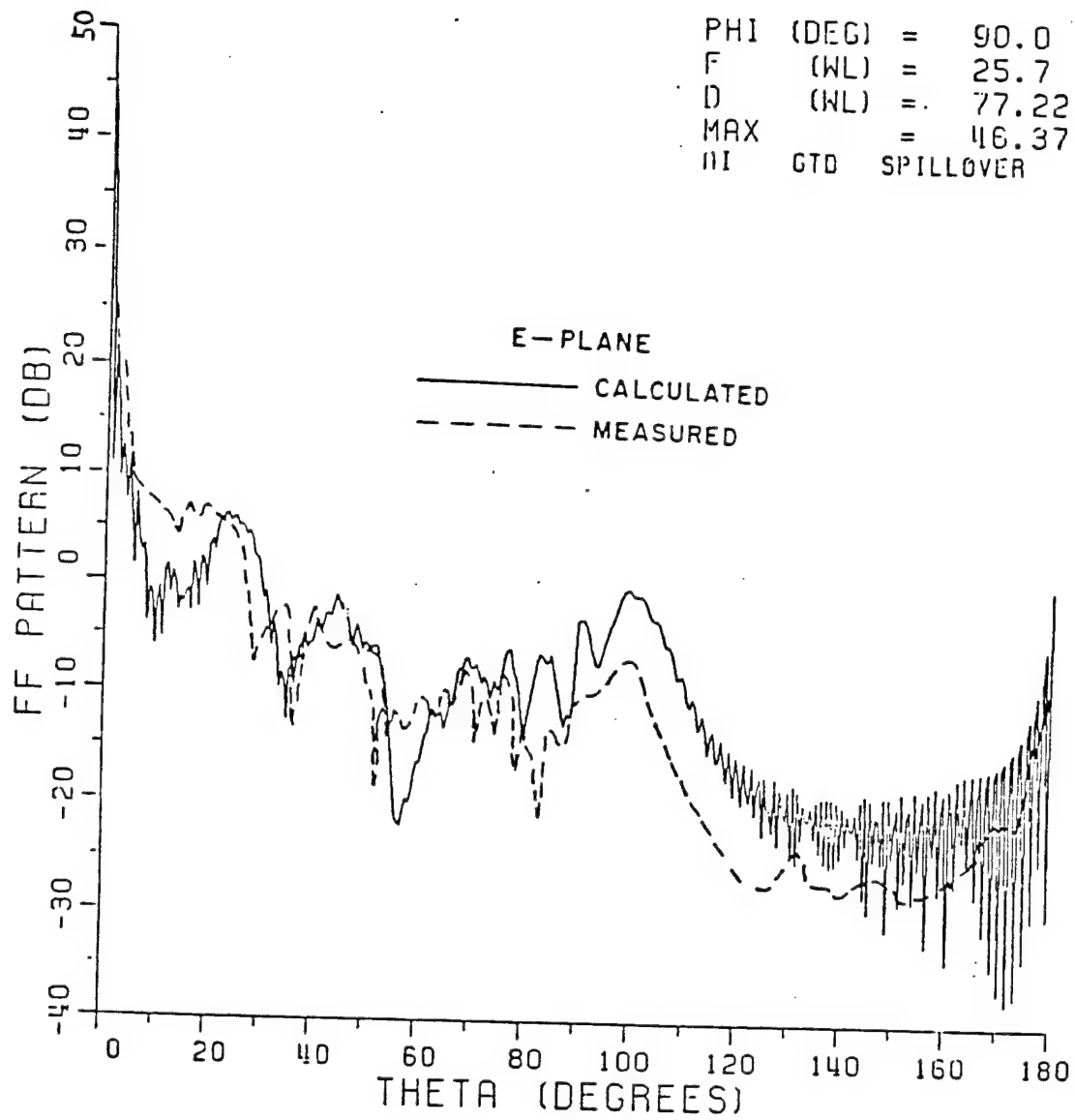


Figure 7. (Continued.)

TABLE 1

INPUT DATA FOR PATTERN CALCULATION OF SUBREFLECTOR

```

CM:      *** SUBREF.DAT ***
CM:      CONICAL HORN FEED WITH
CM:      APERTURE DIAMETER=1.2"
CM:      FLARE ANGLE= 14.9 DEG.
CM:      FEED DATA CALCULATED BY AP: IN CONI.DAT
CE:      SUBREFLECTOR PATTERN CALCULATION
DG:
10
3 - 4.163  0.5  0.5  2.919  0
4.728
FQ:
1 38.0
FD: AD = 0.275"
0 T
T 0 T 1 90. 0.275 F
3 0. 45. 90.
91
    0.000    35.510    71.481    -47.871    -110.173
    1.000    35.478    71.505    -47.992    -111.291
    2.000    35.383    71.578    -48.288    -112.285
    3.000    35.223    71.701    -48.770    -113.173
    4.000    34.999    71.875    -49.454    -113.969
    .         .         .         .         .
    .         .         .         .         .
    .         .         .         .         .
        ( see the example of AP: Command )
    .         .         .         .         .
    .         .         .         .         .
    .         .         .         .         .
    86.000    1.515    -132.115    -70.116    131.990
    87.000    1.319    -132.008    -70.201    132.123
    88.000    1.134    -131.931    -70.306    132.218
    89.000    0.963    -131.885    -70.430    132.274
    90.000   -300.000    0.000   -300.000    0.000
NF:
0. 0. -0.565      ! PHASE REFERENCE OF SUBREFLECTOR PATTERNS
F
F
TO: LAIC=F, LAIS=F, LPO=F, LFEED=T, LGTD=T, LREFL=T
F 90. 1.
F 32 32 1 48
F F F F 0
F T F 0.8
F F F T T 0. 0.
T T 0. 0.
PZ: LFDOUT=T
3
0. 45. 90.
0. 180. 1.
T
PP:
1
1 1
1 2
XQ:

```


TABLE 2

INPUT DATA FOR PATTERN CALCULATION OF MAIN REFLECTOR

```

CM:          *** MAIN.DAT ***
CM:  CALCULATE MAIN REFLECTOR PATTERNS
CM:  FEED DATA CALCULATED FROM SUBREF.DAT
CE:          SUBREFLECTOR BLOCKAGE
DG:
1
3   8.0   0.5   0.5   24.   0
FQ:
1 38.0
FD:
0      T
T      0      T      1      90.   0.   F
3      0.  45.  90.
181

```

0.000	0.967	8.395	-123.560	-71.142
1.000	1.082	7.778	-90.530	-46.993
2.000	1.435	6.196	-105.978	-64.826
3.000	1.956	4.145	-124.967	-161.925
4.000	2.550	2.168	-104.320	-176.473
5.000	3.121	0.639	-127.370	-17.627
6.000	3.593	-0.267	-125.602	-66.099
7.000	3.874	1.039	-131.047	-101.178
8.000	3.889	1.309	-131.781	32.642
9.000	3.826	1.901	-123.943	47.900
10.000	3.706	2.646	-121.349	50.985
11.000	3.559	3.342	-121.309	51.826
12.000	3.417	3.801	-123.247	51.218
13.000	3.311	3.897	-128.319	46.439
14.000	3.265	3.610	-141.442	-21.585
15.000	3.285	3.030	-129.788	-104.446
16.000	3.364	2.336	-125.346	-109.515
17.000	3.486	1.728	-124.394	-109.249
18.000	3.619	1.362	-125.649	-106.278
19.000	3.734	1.312	-129.968	-96.757
20.000	3.807	1.571	-138.812	-35.522
21.000	3.825	2.058	-130.777	41.253
22.000	3.785	2.646	-126.023	52.585
23.000	3.692	3.184	-124.197	56.532
24.000	3.571	3.539	-124.273	58.040
25.000	3.450	3.611	-126.224	57.473
26.000	3.353	3.363	-130.966	51.498
27.000	3.303	2.844	-141.060	-6.898
28.000	3.313	2.178	-132.596	-86.091
29.000	3.380	1.528	-127.823	-93.677
30.000	3.481	1.041	-126.098	-93.787
31.000	3.602	0.827	-126.349	-90.846
32.000	3.717	0.920	-128.378	-84.060
33.000	3.804	1.285	-132.875	-65.842
34.000	3.848	1.840	-136.967	0.533
35.000	3.842	2.470	-131.361	49.657
36.000	3.785	3.049	-127.601	63.333
37.000	3.683	3.458	-125.944	69.386
38.000	3.561	3.609	-125.737	72.702
39.000	3.437	3.449	-126.908	74.274
40.000	3.336	2.986	-129.847	72.987
41.000	3.275	2.290	-136.095	61.282
42.000	3.266	1.480	-141.183	-34.845
43.000	3.303	0.695	-132.360	-69.240
44.000	3.384	0.076	-128.360	-72.981
45.000	3.494	-0.283	-126.469	-72.019
46.000	3.614	-0.334	-125.858	-69.028
47.000	3.725	-0.092	-126.295	-64.255

(TABLE 2 - CONTINUED)

48.000	3.812	0.403	-127.713	-56.796
49.000	3.859	1.071	-130.245	-43.746
50.000	3.858	1.823	-133.655	-16.565
51.000	3.815	2.567	-134.714	31.628
52.000	3.733	3.198	-128.632	34.120
53.000	3.619	3.654	-129.169	49.483
54.000	3.483	3.859	-129.912	65.635
55.000	3.333	3.773	-130.870	83.004
56.000	3.183	3.386	-131.924	102.447
57.000	3.054	2.719	-132.968	124.615
58.000	2.960	1.831	-133.746	149.794
59.000	2.910	0.807	-133.946	176.851
60.000	2.909	-0.248	-133.464	-156.837
61.000	2.944	-1.234	-132.502	-133.476
62.000	3.016	-2.064	-131.367	-113.527
63.000	3.117	-2.672	-130.256	-96.411
64.000	3.237	-3.021	-129.255	-81.386
65.000	3.364	-3.104	-128.414	-67.817
66.000	3.480	-2.933	-127.677	-55.402
67.000	3.576	-2.536	-127.063	-43.794
68.000	3.652	-1.944	-126.558	-32.776
69.000	3.704	-1.196	-126.146	-22.209
70.000	3.729	-0.330	-125.814	-11.989
71.000	3.722	0.616	-125.551	-2.038
72.000	3.674	1.612	-125.368	7.701
73.000	3.597	2.623	-125.205	17.288
74.000	3.491	3.619	-125.076	26.756
75.000	3.357	4.575	-124.969	36.131
76.000	3.189	5.479	-124.873	45.436
77.000	2.986	6.314	-124.777	54.678
78.000	2.759	7.052	-124.671	63.841
79.000	2.509	7.679	-124.541	72.907
80.000	2.238	8.180	-124.384	81.844
81.000	1.927	8.584	-124.189	90.634
82.000	1.596	8.842	-123.951	99.207
83.000	1.247	8.946	-123.668	107.512
84.000	0.881	8.882	-123.342	115.498
85.000	0.478	8.688	-122.995	123.116
86.000	0.050	8.328	-122.580	130.361
87.000	-0.396	7.768	-122.130	137.179
88.000	-0.860	6.998	-121.649	143.556
89.000	-1.372	6.066	-121.139	149.490
90.000	-1.917	4.907	-120.607	154.975
91.000	-2.553	6.360	-119.561	149.359
92.000	-2.723	3.219	-119.100	154.484
93.000	-3.628	-1.867	-118.570	159.414
94.000	-4.930	-2.807	-117.988	163.773
95.000	-5.342	-2.113	-119.006	14.223
96.000	-5.136	-7.017	-119.575	11.252
97.000	-5.721	-14.781	-120.251	7.634
98.000	-6.789	-17.769	-120.990	3.514
99.000	-6.998	-17.620	-121.738	-1.495
100.000	-6.706	-23.629	-122.498	-7.952
101.000	-7.180	-33.313	-123.265	-15.983
102.000	-8.206	-38.625	-123.962	-25.286
103.000	-8.414	-40.311	-124.421	-35.901
104.000	-8.031	-47.854	-124.568	-47.619
105.000	-8.375	-59.257	-124.432	-59.398
106.000	-9.279	-65.931	-124.062	-69.938
107.000	-9.243	-68.409	-123.514	-78.792
108.000	-8.531	-77.667	-122.914	-86.314
109.000	-8.764	-91.749	-122.402	-92.715
110.000	-10.037	-99.590	-122.080	-97.749
111.000	-10.157	-97.850	-121.902	-101.743
112.000	-8.716	-105.381	-121.907	-105.560
113.000	-8.371	-124.184	-122.205	-109.706

(TABLE 2 - CONTINUED)

114.000	-10.167	-142.012	-122.904	-113.894
115.000	-12.893	-140.526	-123.966	-118.228
116.000	-11.275	-132.610	-125.354	-124.327
117.000	-8.882	-152.178	-127.265	-135.534
118.000	-8.674	176.150	-129.672	-156.274
119.000	-11.018	144.553	-131.250	170.848
120.000	-16.360	136.975	-130.103	139.199
121.000	-14.048	168.498	-127.669	121.204
122.000	-8.873	148.539	-125.472	111.054
123.000	-6.900	115.103	-124.009	103.660
124.000	-7.629	81.177	-123.420	97.961
125.000	-11.642	55.124	-123.611	94.174
126.000	-17.757	80.400	-124.398	91.478
127.000	-11.696	97.430	-125.828	87.092
128.000	-8.319	66.666	-128.393	76.540
129.000	-7.550	26.988	-132.577	48.681
130.000	-8.407	-13.563	-133.668	-11.746
131.000	-10.847	-46.476	-129.444	-46.544
132.000	-14.359	-51.909	-126.347	-57.913
133.000	-12.254	-36.506	-124.508	-62.648
134.000	-8.573	-52.061	-123.699	-66.192
135.000	-7.354	-80.123	-124.016	-70.324
136.000	-8.537	-111.299	-125.739	-75.666
137.000	-12.240	-139.766	-129.443	-84.774
138.000	-17.524	-141.113	-136.273	-118.016
139.000	-13.566	-126.662	-134.006	159.660
140.000	-7.798	-154.211	-127.847	138.908
141.000	-4.055	170.506	-124.578	131.720
142.000	-2.084	134.759	-123.171	126.337
143.000	-1.716	97.941	-123.434	120.790
144.000	-2.773	57.522	-125.637	114.372
145.000	-4.811	10.509	-130.873	102.363
146.000	-7.185	-42.313	-139.789	25.751
147.000	-10.738	-97.049	-130.656	-36.306
148.000	-18.547	166.132	-125.977	-41.811
149.000	-9.374	52.100	-123.711	-42.512
150.000	-3.399	9.179	-123.007	-43.618
151.000	-0.622	-27.103	-123.981	-47.454
152.000	0.511	-64.930	-127.491	-58.417
153.000	1.028	-106.879	-135.410	-112.772
154.000	1.773	-150.367	-128.474	164.551
155.000	2.655	169.735	-123.284	148.255
156.000	2.982	133.899	-121.297	140.515
157.000	2.346	98.230	-121.502	134.297
158.000	0.955	56.745	-124.004	126.351
159.000	0.169	6.055	-130.912	105.643
160.000	1.100	-43.307	-132.447	-2.658
161.000	2.352	-83.833	-124.636	-28.435
162.000	3.025	-121.222	-121.514	-35.673
163.000	3.603	-160.794	-120.732	-37.259
164.000	3.121	159.640	-122.514	-40.537
165.000	3.186	121.981	-127.833	-41.935
166.000	3.582	91.819	-149.018	159.574
167.000	3.284	67.246	-126.600	145.894
168.000	1.840	42.724	-121.729	145.149
169.000	-0.566	9.675	-120.158	146.036
170.000	-1.587	-38.024	-120.284	148.279
171.000	0.356	-77.615	-123.674	150.846
172.000	2.090	-100.324	-135.072	156.949
173.000	2.296	-115.463	-126.944	-33.554
174.000	0.664	-132.219	-128.067	13.192
175.000	-2.889	-161.415	-121.323	65.996
176.000	-3.472	137.785	-101.095	-75.063
177.000	1.231	102.703	-111.180	-79.016
178.000	4.529	91.185	-100.571	-103.429
179.000	6.297	86.110	-91.446	58.021

(TABLE 2 - CONTINUED)

180.000	6.886	84.371	-113.952	37.563
0.000	0.967	8.395	-123.048	-63.194
1.000	1.143	7.866	-38.904	157.565
2.000	1.641	6.510	-27.562	159.050
3.000	2.331	4.825	-21.518	159.313
4.000	3.054	3.313	-17.959	159.588
5.000	3.679	2.256	-16.041	159.893
6.000	4.121	1.739	-15.457	160.273
7.000	4.453	0.130	-17.175	158.870
8.000	4.440	0.398	-17.402	159.474
9.000	4.220	1.176	-20.014	160.257
10.000	3.857	2.275	-26.958	162.007
11.000	3.436	3.437	-36.132	-25.388
12.000	3.052	4.356	-23.486	-20.141
13.000	2.798	4.759	-20.143	-18.862
14.000	2.732	4.534	-19.639	-17.785
15.000	2.858	3.800	-21.386	-16.544
16.000	3.127	2.843	-26.446	-14.461
17.000	3.465	1.977	-52.327	44.052
18.000	3.786	1.408	-27.372	162.220
19.000	4.021	1.226	-22.550	164.595
20.000	4.127	1.409	-21.123	166.195
21.000	4.091	1.875	-21.842	167.810
22.000	3.925	2.497	-24.973	169.936
23.000	3.656	3.123	-33.629	175.639
24.000	3.349	3.597	-34.860	-17.874
25.000	3.066	3.783	-25.827	-11.242
26.000	2.869	3.619	-22.823	-8.811
27.000	2.802	3.152	-22.190	-6.789
28.000	2.876	2.534	-23.449	-4.626
29.000	3.065	1.956	-27.165	-1.577
30.000	3.312	1.574	-37.803	9.430
31.000	3.568	1.469	-33.920	169.660
32.000	3.782	1.640	-26.432	176.327
33.000	3.917	2.025	-23.665	179.261
34.000	3.953	2.533	-22.956	-178.282
35.000	3.886	3.053	-23.878	-175.732
36.000	3.725	3.478	-26.730	-172.471
37.000	3.491	3.708	-33.525	-165.437
38.000	3.228	3.670	-42.176	-18.272
39.000	2.977	3.340	-29.614	3.649
40.000	2.780	2.760	-25.507	8.068
41.000	2.670	2.038	-23.814	11.125
42.000	2.660	1.332	-23.586	13.933
43.000	2.734	0.796	-24.668	16.926
44.000	2.878	0.539	-27.353	20.705
45.000	3.063	0.605	-33.075	27.920
46.000	3.257	0.977	-47.750	128.511
47.000	3.427	1.581	-32.425	-166.778
48.000	3.553	2.339	-27.395	-160.205
49.000	3.614	3.149	-25.019	-156.375
50.000	3.601	3.921	-24.018	-153.154
51.000	3.522	4.561	-24.019	-150.050
52.000	3.213	5.002	-29.394	-121.519
53.000	3.033	5.483	-29.406	-101.627
54.000	2.835	5.620	-29.416	-82.155
55.000	2.629	5.394	-29.422	-63.056
56.000	2.432	4.817	-29.425	-44.351
57.000	2.271	3.936	-29.428	-26.068
58.000	2.160	2.848	-29.430	-8.191
59.000	2.106	1.676	-29.424	9.275
60.000	2.110	0.551	-29.421	26.318
61.000	2.149	-0.401	-29.416	42.945
62.000	2.222	-1.106	-29.407	59.134
63.000	2.319	-1.516	-29.395	74.879
64.000	2.425	-1.617	-29.382	90.192

(TABLE 2 - CONTINUED)

65.000	2.530	-1.423	-29.366	105.068
66.000	2.613	-0.955	-29.348	119.498
67.000	2.662	-0.254	-29.329	133.451
68.000	2.686	0.627	-29.308	146.951
69.000	2.680	1.643	-29.285	159.988
70.000	2.643	2.750	-29.258	172.558
71.000	2.568	3.920	-29.230	-175.348
72.000	2.445	5.136	-29.200	-163.733
73.000	2.292	6.342	-29.169	-152.602
74.000	2.110	7.511	-29.136	-141.960
75.000	1.899	8.618	-29.101	-131.810
76.000	1.651	9.682	-29.065	-122.154
77.000	1.364	10.691	-29.027	-112.998
78.000	1.054	11.595	-28.988	-104.345
79.000	0.723	12.381	-28.948	-96.200
80.000	0.372	13.038	-28.905	-88.569
81.000	-0.028	13.687	-28.862	-81.457
82.000	-0.448	14.202	-28.816	-74.868
83.000	-0.886	14.576	-28.768	-68.809
84.000	-1.341	14.801	-28.719	-63.283
85.000	-1.844	15.028	-28.667	-58.296
86.000	-2.380	15.164	-28.613	-53.847
87.000	-2.938	15.144	-28.555	-49.950
88.000	-12.344	164.489	-28.494	-46.611
89.000	-11.897	169.730	-28.428	-43.828
90.000	-11.445	174.602	-28.356	-41.609
91.000	-11.016	-175.870	-19.497	121.243
92.000	-10.541	-171.972	-16.802	38.902
93.000	-10.073	-168.410	-17.259	-36.145
94.000	-9.611	-165.177	-19.599	-129.047
95.000	-9.277	7.385	-18.958	119.218
96.000	-9.632	4.007	-16.070	38.164
97.000	-9.971	0.427	-16.373	-36.418
98.000	-10.297	-3.324	-18.501	-125.550
99.000	-10.616	-7.217	-18.497	130.934
100.000	-10.935	-11.231	-16.773	39.452
101.000	-11.264	-15.358	-15.781	-42.951
102.000	-11.614	-19.608	-16.029	-122.128
103.000	-11.999	-24.011	-18.143	152.054
104.000	-12.435	-28.629	-18.733	41.265
105.000	-12.934	-33.559	-14.999	-48.698
106.000	-13.511	-38.947	-13.771	-114.560
107.000	-14.174	-44.999	-17.045	-179.689
108.000	-14.926	-51.997	-23.175	47.780
109.000	-15.747	-60.301	-14.840	-50.512
110.000	-16.589	-70.308	-12.586	-104.933
111.000	-17.350	-82.296	-15.572	-155.503
112.000	-17.886	-96.114	-31.347	100.294
113.000	-18.070	-110.881	-17.048	-46.951
114.000	-17.887	-125.209	-13.958	-95.652
115.000	-17.464	-137.980	-16.304	-143.488
116.000	-16.981	-148.825	-26.158	153.879
117.000	-16.594	-157.980	-26.516	-29.720
118.000	-16.409	-165.950	-22.530	-102.627
119.000	-16.499	-173.324	-22.208	176.662
120.000	-16.923	179.232	-21.879	109.879
121.000	-17.727	170.867	-27.907	89.702
122.000	-18.943	160.299	-20.673	153.452
123.000	-20.494	145.445	-13.977	123.793
124.000	-21.953	123.765	-12.873	84.922
125.000	-22.359	96.297	-17.393	37.869
126.000	-21.360	71.195	-23.943	-125.896
127.000	-19.886	53.391	-13.125	161.027
128.000	-18.710	41.218	-10.367	107.371
129.000	-18.097	32.077	-10.012	45.000
130.000	-18.138	24.074	-9.434	-23.032

(TABLE 2 - CONTINUED)

131.000	-18.908	15.572	-9.109	-83.997
132.000	-20.516	4.273	-11.301	-144.182
133.000	-22.958	-14.596	-15.040	119.867
134.000	-25.067	-49.050	-10.014	26.587
135.000	-24.005	-89.187	-6.675	-26.338
136.000	-21.406	-113.440	-6.420	-73.276
137.000	-19.516	-126.700	-8.311	-125.962
138.000	-18.664	-135.565	-10.587	170.781
139.000	-18.865	-143.285	-12.463	111.840
140.000	-20.237	-152.437	-18.950	69.393
141.000	-23.058	-167.949	-19.962	-162.909
142.000	-26.790	155.230	-10.157	166.680
143.000	-25.593	99.698	-7.625	130.548
144.000	-21.774	72.879	-8.386	86.059
145.000	-19.455	60.856	-10.291	21.468
146.000	-18.648	53.193	-9.322	-50.572
147.000	-19.273	46.076	-8.298	-107.620
148.000	-21.603	35.912	-9.148	-171.024
149.000	-26.327	10.905	-7.247	109.496
150.000	-28.144	-60.304	-2.835	53.305
151.000	-22.661	-98.779	-0.060	12.541
152.000	-19.454	-111.230	1.071	-26.026
153.000	-18.290	-118.061	1.348	-68.206
154.000	-18.873	-124.054	1.832	-113.652
155.000	-21.564	-132.927	2.787	-155.895
156.000	-27.820	-160.568	3.396	167.843
157.000	-27.697	107.218	2.998	134.388
158.000	-21.131	79.684	1.428	98.215
159.000	-18.196	71.397	-0.686	52.274
160.000	-17.502	66.474	-1.413	-2.440
161.000	-18.863	61.436	-0.771	-51.378
162.000	-23.280	51.187	-0.501	-96.343
163.000	-32.740	-22.193	0.036	-147.008
164.000	-22.751	-93.849	-0.261	168.168
165.000	-17.927	-103.490	0.340	128.896
166.000	-16.203	-107.588	1.176	100.487
167.000	-16.688	-110.831	0.989	78.534
168.000	-19.926	-115.819	-0.656	56.283
169.000	-30.526	-143.949	-3.636	22.930
170.000	-23.418	87.685	-4.605	-31.198
171.000	-16.655	78.274	-1.747	-70.944
172.000	-14.057	75.350	0.335	-90.787
173.000	-13.824	73.536	0.602	-103.521
174.000	-12.167	75.921	-2.290	-114.182
175.000	-12.749	75.249	-9.559	-148.402
176.000	-14.669	74.782	-6.047	109.295
177.000	-18.225	74.437	1.039	91.209
178.000	-24.278	74.069	4.524	87.007
179.000	-35.629	72.724	6.287	85.284
180.000	-126.056	-140.389	6.886	84.371
0.000	0.967	8.395	-123.560	-71.142
1.000	1.210	7.958	-108.371	44.911
2.000	1.861	6.773	-108.842	-97.689
3.000	2.718	5.288	-119.681	-2.060
4.000	3.577	3.892	-126.287	-23.311
5.000	4.281	2.773	-133.494	-69.934
6.000	4.739	1.983	-126.804	-44.951
7.000	4.653	3.521	-134.996	11.195
8.000	4.618	3.677	-134.950	2.367
9.000	4.333	3.636	-135.487	-6.151
10.000	3.876	3.377	-136.588	-14.116
11.000	3.349	2.914	-138.240	-20.795
12.000	2.878	2.319	-140.439	-24.253
13.000	2.581	1.743	-143.030	-20.444
14.000	2.530	1.376	-144.761	-4.316
15.000	2.714	1.343	-143.809	15.470

(TABLE 2 - CONTINUED)

16.000	3.056	1.651	-141.367	24.313
17.000	3.459	2.198	-139.124	24.548
18.000	3.821	2.839	-137.477	20.746
19.000	4.067	3.444	-136.424	15.226
20.000	4.157	3.898	-135.912	8.941
21.000	4.082	4.118	-135.898	2.312
22.000	3.862	4.040	-136.341	-4.418
23.000	3.535	3.648	-137.212	-10.839
24.000	3.179	2.974	-138.470	-16.312
25.000	2.870	2.143	-140.064	-19.604
26.000	2.676	1.356	-141.846	-18.521
27.000	2.633	0.837	-143.340	-10.494
28.000	2.740	0.742	-143.623	3.359
29.000	2.955	1.098	-142.431	15.375
30.000	3.209	1.814	-140.674	21.092
31.000	3.457	2.727	-139.058	21.847
32.000	3.648	3.663	-137.819	19.738
33.000	3.748	4.465	-136.994	16.040
34.000	3.744	5.006	-136.564	11.388
35.000	3.636	5.195	-136.481	6.137
36.000	3.439	4.984	-136.715	0.529
37.000	3.180	4.376	-137.230	-5.210
38.000	2.910	3.430	-137.980	-10.746
39.000	2.673	2.289	-138.928	-15.558
40.000	2.505	1.162	-140.035	-18.869
41.000	2.427	0.275	-141.242	-19.607
42.000	2.438	-0.191	-142.407	-16.565
43.000	2.509	-0.141	-143.254	-9.104
44.000	2.624	0.409	-143.394	1.416
45.000	2.760	1.356	-142.737	11.467
46.000	2.889	2.560	-141.628	18.422
47.000	2.989	3.855	-140.459	22.011
48.000	3.045	5.099	-139.441	23.043
49.000	3.036	6.173	-138.658	22.328
50.000	2.960	6.978	-138.115	20.402
51.000	2.832	7.422	-137.787	17.568
52.000	2.441	6.683	-140.084	6.671
53.000	2.213	6.715	-140.315	6.689
54.000	1.994	6.369	-140.536	6.330
55.000	1.793	5.705	-140.739	5.655
56.000	1.624	4.806	-140.909	4.745
57.000	1.511	3.768	-141.024	3.702
58.000	1.456	2.726	-141.079	2.661
59.000	1.455	1.808	-141.082	1.751
60.000	1.496	1.116	-141.042	1.073
61.000	1.545	0.745	-140.995	0.721
62.000	1.601	0.693	-140.943	0.693
63.000	1.657	0.946	-140.891	0.971
64.000	1.701	1.477	-140.853	1.527
65.000	1.725	2.241	-140.835	2.316
66.000	1.711	3.219	-140.857	3.315
67.000	1.649	4.379	-140.928	4.494
68.000	1.554	5.634	-141.032	5.763
69.000	1.427	6.941	-141.170	7.079
70.000	1.267	8.261	-141.341	8.401
71.000	1.066	9.595	-141.554	9.732
72.000	0.811	10.973	-141.820	11.099
73.000	0.529	12.283	-142.115	12.389
74.000	0.220	13.503	-142.437	13.580
75.000	-0.113	14.612	-142.782	14.652
76.000	-0.486	15.711	-143.168	15.701
77.000	-0.899	16.802	-143.593	16.732
78.000	-1.330	17.761	-144.037	17.618
79.000	-1.778	18.581	-144.495	18.352
80.000	-2.240	19.253	-144.967	18.925
81.000	-2.763	20.180	-145.498	19.738

(TABLE 2 - CONTINUED)

82.000	-3.302	20.986	-146.044	20.413
83.000	-3.856	21.659	-146.603	20.938
84.000	-4.426	22.192	-147.174	21.306
85.000	-5.052	23.127	-147.800	22.052
86.000	-5.717	24.163	-148.461	22.874
87.000	-6.410	25.098	-149.146	23.563
88.000	-7.137	25.929	-149.859	24.113
89.000	-7.934	27.678	-150.640	25.524
90.000	-8.797	29.780	-151.482	27.216
91.000	-6.894	0.484	-148.344	-16.725
92.000	-18.200	-11.106	-148.576	-16.249
93.000	-10.874	77.345	-148.892	-16.462
94.000	-7.008	41.726	-149.657	-16.291
95.000	-9.582	-4.731	-149.645	-8.230
96.000	-23.772	-81.953	-148.810	-5.792
97.000	-11.906	93.435	-148.414	-8.293
98.000	-7.499	39.802	-149.023	-7.558
99.000	-8.685	-13.869	-149.105	1.380
100.000	-17.197	-89.486	-148.004	5.063
101.000	-13.145	102.643	-147.904	1.059
102.000	-7.699	39.587	-149.391	3.439
103.000	-7.980	-17.712	-149.688	18.939
104.000	-13.526	-92.381	-148.304	22.707
105.000	-13.795	124.896	-148.867	16.127
106.000	-8.428	47.382	-152.028	22.285
107.000	-8.046	-16.087	-152.133	51.304
108.000	-11.181	-92.745	-150.251	52.323
109.000	-12.637	158.138	-152.425	42.005
110.000	-10.031	68.311	-159.654	73.363
111.000	-9.498	-7.565	-154.119	119.383
112.000	-10.202	-88.751	-152.643	108.530
113.000	-10.592	-171.804	-158.388	113.013
114.000	-11.775	106.971	-155.670	-172.593
115.000	-13.215	12.420	-150.573	-177.906
116.000	-11.403	-78.644	-151.225	172.105
117.000	-10.477	-146.432	-154.686	-165.454
118.000	-13.337	150.701	-151.474	-134.857
119.000	-20.425	48.160	-149.593	-139.022
120.000	-16.017	-66.398	-151.620	-141.711
121.000	-15.061	-125.226	-154.447	-116.226
122.000	-22.027	176.509	-153.209	-96.305
123.000	-23.835	-14.532	-154.992	-93.396
124.000	-17.874	-80.593	-159.169	-48.148
125.000	-19.409	-168.018	-154.261	-18.339
126.000	-14.850	84.520	-154.579	-24.324
127.000	-10.714	17.928	-162.049	28.088
128.000	-10.145	-47.197	-151.447	69.991
129.000	-10.061	-129.731	-147.878	50.578
130.000	-7.329	151.685	-149.828	23.129
131.000	-5.465	88.954	-164.406	-38.737
132.000	-5.620	25.468	-151.496	161.625
133.000	-5.886	-50.035	-147.536	125.276
134.000	-4.199	-123.032	-149.294	80.832
135.000	-2.897	176.848	-152.505	-9.266
136.000	-3.216	118.732	-147.352	-85.919
137.000	-4.208	52.928	-145.211	-127.239
138.000	-4.089	-15.320	-147.188	-164.968
139.000	-3.911	-74.246	-154.608	133.344
140.000	-5.456	-130.236	-152.638	12.120
141.000	-8.351	159.964	-149.009	-35.315
142.000	-8.361	78.855	-151.072	-76.168
143.000	-7.437	18.387	-157.705	-160.880
144.000	-9.546	-36.077	-152.278	104.122
145.000	-14.118	-123.312	-150.306	63.331
146.000	-10.246	139.402	-154.792	21.759
147.000	-7.191	79.624	-159.212	-130.381

(TABLE 2 - CONTINUED)

148.000	-5.950	16.532	-148.652	173.045
149.000	-3.189	-49.164	-145.300	132.897
150.000	0.210	-100.484	-143.992	85.835
151.000	2.431	-142.558	-142.335	33.572
152.000	3.450	176.693	-140.091	-12.930
153.000	3.908	133.344	-138.407	-52.429
154.000	4.568	88.690	-137.622	-89.613
155.000	5.464	47.481	-137.447	-127.713
156.000	5.985	11.041	-137.452	-166.868
157.000	5.714	-23.198	-137.460	154.887
158.000	4.637	-58.896	-137.749	118.969
159.000	3.189	-98.981	-138.500	85.279
160.000	2.029	-142.197	-140.106	49.791
161.000	0.969	176.041	-142.455	10.842
162.000	-1.089	132.861	-145.656	-36.659
163.000	-3.617	68.768	-148.418	-108.961
164.000	-3.954	14.578	-143.697	-157.234
165.000	-2.785	-25.604	-144.035	166.474
166.000	-1.611	-52.040	-143.844	134.127
167.000	-1.739	-71.742	-143.912	106.757
168.000	-3.557	-92.097	-146.741	81.996
169.000	-7.069	-125.711	-148.707	51.470
170.000	-7.892	173.963	-149.858	7.639
171.000	-4.239	135.206	-148.471	-33.268
172.000	-1.952	117.796	-146.925	-59.668
173.000	-1.660	106.856	-146.352	-80.852
174.000	-3.881	93.067	-125.159	-119.108
175.000	-15.556	119.334	-126.578	-89.548
176.000	-5.983	-107.781	-123.165	-74.731
177.000	1.144	-100.359	-124.399	-129.605
178.000	4.542	-97.221	-102.520	111.021
179.000	6.281	-95.619	-94.737	-10.519
180.000	6.886	-95.629	-101.403	27.062

TO: LAIC=T, LGTD=T, LFEED=T

F 90. 1.

F 32 32 1 48

F F F F 0

T T F 0.8

T F F T T F 0. 0.

T T 0. 0.

FB:

1 0. 0. 8.

2.92

PZ:

2

0. 90.

0. 180. 0.5

F

PP:

1

1 1

1 2

XQ:

Example 2:

This example simply illustrates the radiation patterns of an offset reflector with an elliptic rim. The length of the major and minor axis of the ellipse are DAA=12.0" and DBB=10.0". The center of the ellipse is offset along the y-axis by 5.0" and the feed is tilted by 32.0 degrees, as specified by the TL: command. The calculated patterns are shown in Figure 8. The input data are given in Table 3.

TABLE 3
INPUT DATA FOR THE EXAMPLE OF ELLIPTIC RIM REFLECTOR

```

CM:          *** ELRIM.DAT ***
CM: EXAMPLE OF ELLIPTIC RIM REFLECTOR
CM:          D = -1 IN DG: COMMAND
CE: YC = 5.0" , PSIT = 32.0 DEG. IN TL:
DG: DAA = 12.0" DBB = 10.0"
1
3  8.0  0.6  0.6  -1  0
12. 10.
TL:
32. 5.
PZ:
2
0. 90.
-180. 180. 1.
F
PP:
1
1 1
1 2
XQ:

```

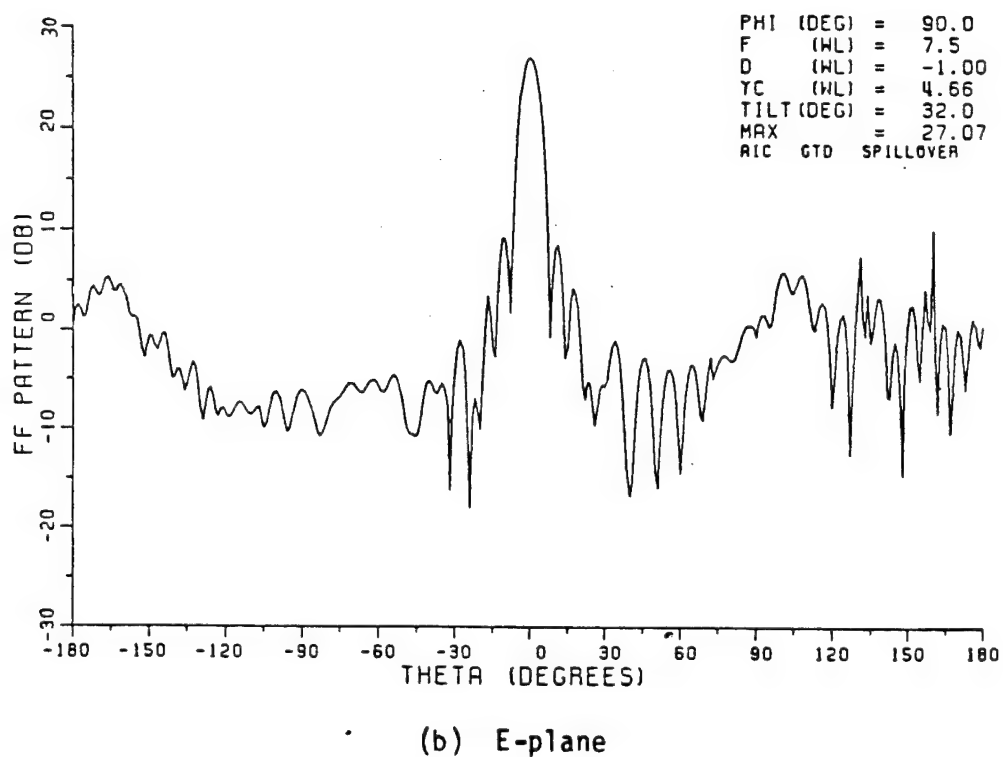
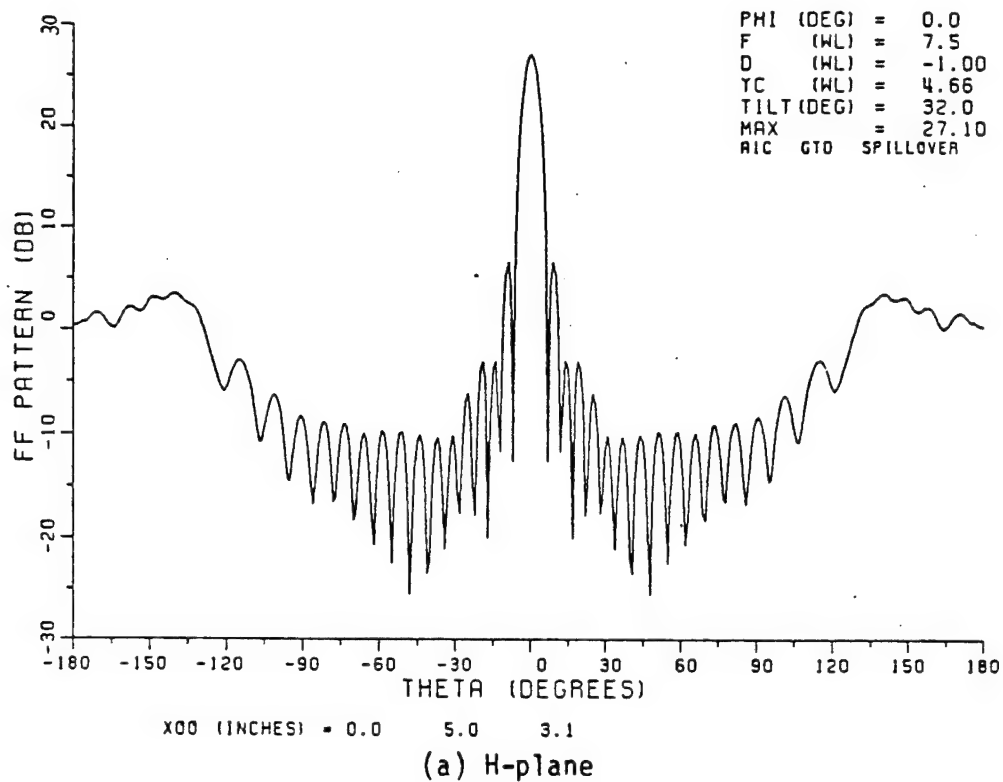
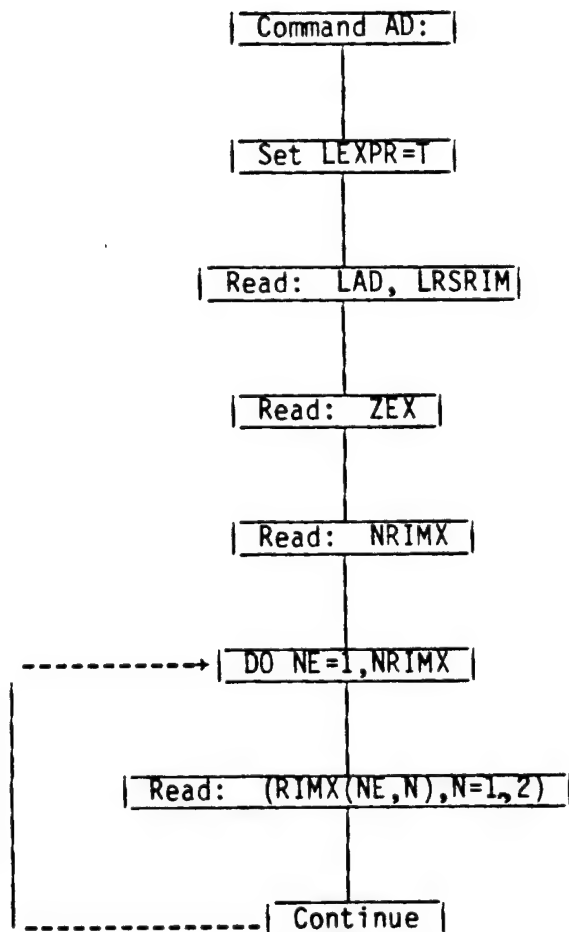


Figure 8. Calculated patterns of an offset reflector antenna with elliptic rim ($D=-1$).

Command AD: Extended Aperture Integration (AIE)

This command enables the user to specify the extended aperture and provides the capability for the diffracted fields to be included in the aperture fields for the Extended Aperture Integration (AIE) method [7]. This command can also be used to calculate the blockage effects by the feed structure besides using the FB: Command.

BLOCK DIAGRAM FOR AD: COMMAND



1. Read: LAD, LRSRIM

- a) LAD: This logical variable specifies whether or not the diffracted fields from the reflector rim will be added to the original G.O. aperture fields. If LAD = true, the diffracted fields will be added.
- b) LRSRIM: This logical variable specifies whether the rim points (x,y components) of the extended aperture will be set identical to the rim points of the reflector when LAD=false. If LRSRIM=true, the extended aperture rim is set identical to the reflector rim. If LRSRIM =false, the extended aperture rim is specified by NRIMX and RIMX. If LAD=true, this variable is ignored by the code.

2. Read: ZEX

- a) This real variable specifies the Z coordinate of the extended aperture as shown in Figure 1a.

Note: The phase center for extended aperture integration is at the point (0., 0., ZEX).

3. Read: NRIMX

- a) NRIMX: This integer specifies the number of input rim points for the extended aperture.

4. Read: (RIMX(NE,N),N=1,2)

This read statement is executed NRIMX times for each rim point.

- a) RIMX(NE,N): This doubly dimensioned real variable is used to specify the location of the NEth corner of the extended aperture as shown in Figure 1b. Presently, 112 rim points may be used.

Note: The rim points RIMX(NE,N) must be input in the counterclockwise order.

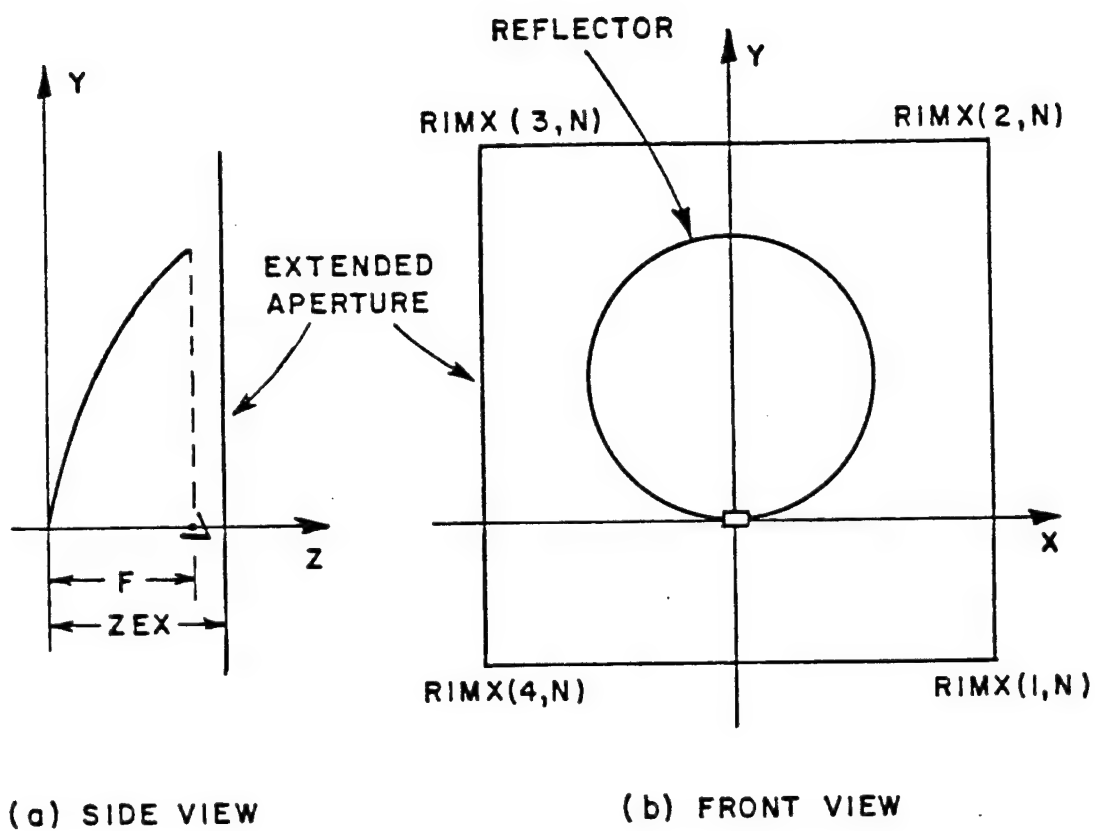


Figure 1. An example to show the position and size of the extended aperture.

Three examples are given in this section to illustrate how to use the AD: Command. The first example shows the calculation of an offset reflector pattern by the AIE method. The second and third examples show the calculation of feed blockage effects by the AD: Command.

Example 1:

This example illustrates how the extended aperture integration (AIE) is used to calculate the far-field pattern of an offset reflector. The results from multi-point GTD and the conventional aperture integration (AIC) are also given for comparison. The geometries of the reflector and the extended aperture are given in Figure 1 with ZEX=7.0". The far-field patterns for AIE, AIC and multi-point GTD are shown in Figure 2. It is found that AIE and Multi-point GTD are in good agreement at wide angles. The input data for AIE, AIC, and GTD are given in Tables 1, 2 and 3, respectively.

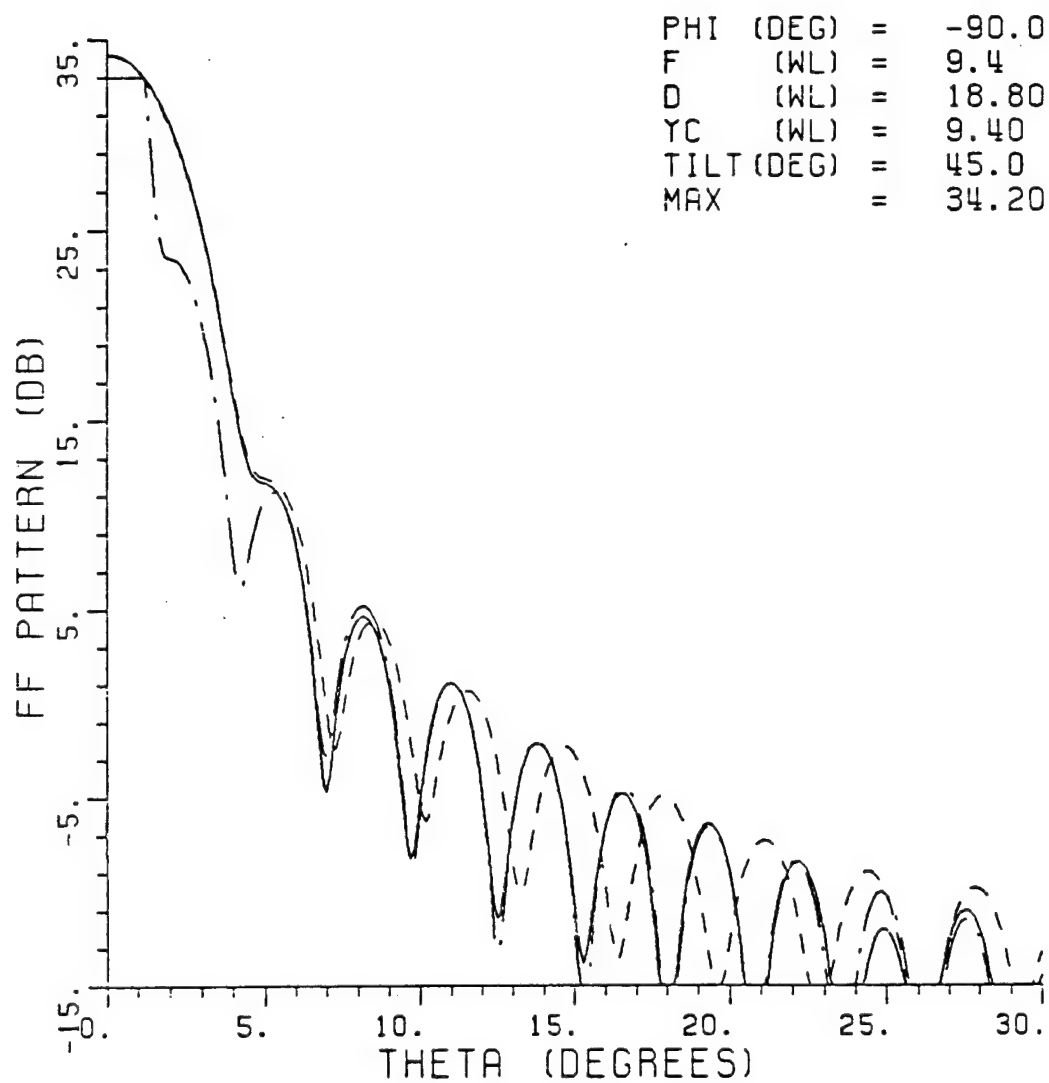


Figure 2. Far field patterns of the offset reflector.

— AIE
 - - - AIC
 - . - Multi-point GTD

TABLE 1

INPUT DATA FOR THE PATTERN CALCULATION BY AIE

```

CM:      ***** CHUAIE.DAT *****
CM:      EXTENDED APERTURE INTEGRATION
CM:      FOR AN OFFSET CIRCULAR REFLECTOR
CE:
DG:
1
3  6. 0.3 0.3 12. 0
TO: AIE ONLY
F  90.  5.
F  0  0  0  0
F  F  F  F  0
T:  T  F  0.8
F  F  F  F  F  F  0.  0.
F  F  0.  0.
AD:  LAD=T
T F
7.
4
-11. -6.
 11. -6.
 11. 16.
-11. 16.
FD:
0  T
T  0  T  1  90.  0.  F
2  0. 90.
9
0.  0.  0.  -300.  0.
5.  -0.1 0.  -300.  0.
10. -0.5 0.  -300.  0.
15. -1.2 0.  -300.  0.
20. -2.1 0.  -300.  0.
30. -4.6 0.  -300.  0.
35. -6.35 0.  -300.  0.
45. -10.15 0.  -300.  0.
60. -17.0 0.  -300.  0.
0.  0.  0.  -300.  0.
5.  -0.1 0.  -300.  0.
10. -0.5 0.  -300.  0.
15. -1.2 0.  -300.  0.
20. -2.1 0.  -300.  0.
30. -4.6 0.  -300.  0.
35. -6.35 0.  -300.  0.
45. -10.15 0.  -300.  0.
60. -17.0 0.  -300.  0.
FQ:
1  18.5
TL:
45.  6.
PZ:
1
-90.
0.  30.  0.1
F
PP:
1
1  1
1  2
XQ:

```

TABLE 2
INPUT DATA FOR THE PATTERN CALCULATION BY AIC

```

CM:          ***** CHUAIC.DAT *****
CM:  CONVENTIONAL APERTURE INTEGRATION
CE:    FOR AN OFFSET CIRCULAR REFLECTOR
DG:
1
3  6. 0.3 0.3 12. 0
TO: AIC ONLY
F 90. 5.
F  0  0  0  0
F  F  F  F  0
T  T  F  0.8
T: F  F  F  F  F  0.  0.
F  F  0.  0.
FD:
0  T
T  0  T  1  90. 0.  F
2  0. 90.
9
0.  0.  0.  -300. 0.
5.  -0.1 0.  -300. 0.
10. -0.5 0.  -300. 0.
15. -1.2 0.  -300. 0.
20. -2.1 0.  -300. 0.
30. -4.6 0.  -300. 0.
35. -6.35 0. -300. 0.
45. -10.15 0. -300. 0.
60. -17.0 0. -300. 0.
0.  0.  0.  -300. 0.
5.  -0.1 0.  -300. 0.
10. -0.5 0.  -300. 0.
15. -1.2 0.  -300. 0.
20. -2.1 0.  -300. 0.
30. -4.6 0.  -300. 0.
35. -6.35 0. -300. 0.
45. -10.15 0. -300. 0.
60. -17.0 0. -300. 0.
FQ:
1  18.5
TL:
45. 6.
PZ:
1
-90.
0.  30. 0.1
F
PP:
1
1  1
1  2
XQ:

```

TABLE 3
INPUT DATA FOR THE PATTERN CALCULATION BY GTD

```

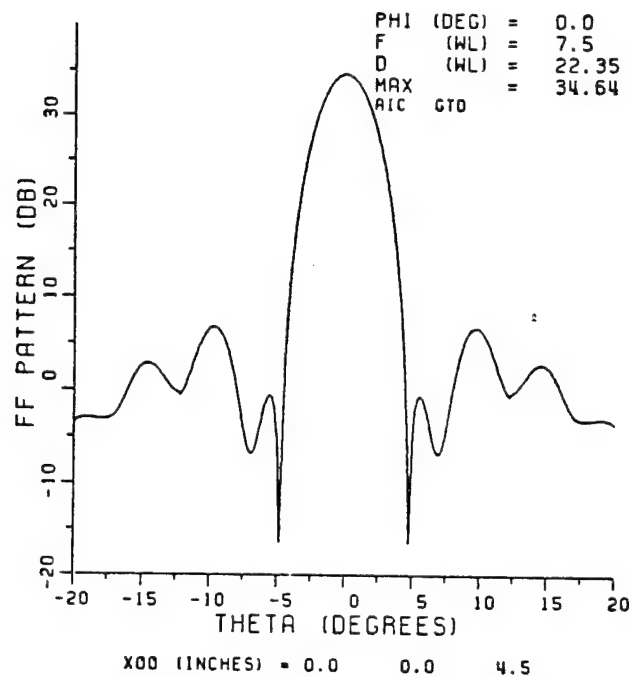
CM:      ***** CHUGTD.DAT *****
CM:      MULTI-POINT GTD
CE: FOR AN OFFSET CIRCULAR REFLECTOR
DG:
1
3 6. 0.3 0.3 12. 0
TO: GTD ONLY
F 90. 5.
F 0 0 0 0
F F F F 0
T T F 0.8
F F F F T F 0. 0.
T F 0. 0.
FD:
0 T
T 0 T 1 90. 0. F
2 0. 90.
9
0. 0. 0. -300. 0.
5. -0.1 0. -300. 0.
10. -0.5 0. -300. 0.
15. -1.2 0. -300. 0.
20. -2.1 0. -300. 0.
30. -4.6 0. -300. 0.
35. -6.35 0. -300. 0.
45. -10.15 0. -300. 0.
60. -17.0 0. -300. 0.
0. 0. 0. -300. 0.
5. -0.1 0. -300. 0.
10. -0.5 0. -300. 0.
15. -1.2 0. -300. 0.
20. -2.1 0. -300. 0.
30. -4.6 0. -300. 0.
35. -6.35 0. -300. 0.
45. -10.15 0. -300. 0.
60. -17.0 0. -300. 0.
FQ:
1 18.5
TL:
45. 6.
PZ:
1
-90.
0. 30. 0.1
F
PP:
1
1 1
1 2
XQ:

```

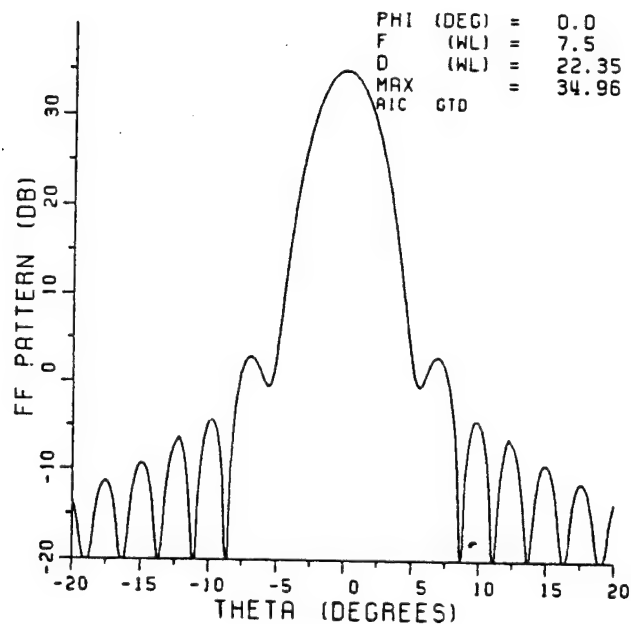
Example 2:

This example illustrates the feed/plate scattering model in which the forward scattered fields of a flat plate can be computed by the Extended Aperture Integration. The plate must be perpendicular to the axis of reflector. The default reflector with a square (2.4" x 2.4") feed blockage model is used since the scattering fields of the feed blockage can also be obtained by using the FB: command. The patterns obtained from the FB: command are given in Figure 3 for the total, reflector and feed scattering fields. The scattering fields of the feed blockage are computed by the physical optics solution for the scattering of a flat plate. Next the AD: command is used to calculate the scattered fields of the square plate. Then the total fields are obtained by subtracting the scattering fields from the reflector fields. This is done in a separate computer code (named FDSCAT23) which processes the output data from the reflector code. The resultant patterns of the total and feed scattering fields are shown in Figure 4. As can be seen by comparing Figures 3 and 4, the two feed scattering models are in very good agreement. Note that when the AD: command model is used, the phase reference point must be identical for the reflector fields and the scattered fields. The input data for the scattered field computation by AIE are given in Table 4. The input data for the computation by FB: Command are given in Table 5.

Note that in order to use FDSCAT23.FOR to calculate the total field, two data files have to be generated. One is the file for the scattered field and the other is the file for the reflector field. These data files are generated by using the PP: Command. Thus, the format of PP: Command must be the same. In this example, the reflector field can be calculated by using the input data given in Table 4 except that the AD: Command has to be deleted and the grid sizes in the DG: Command have to be changed so that the number of grids does not exceed 200.

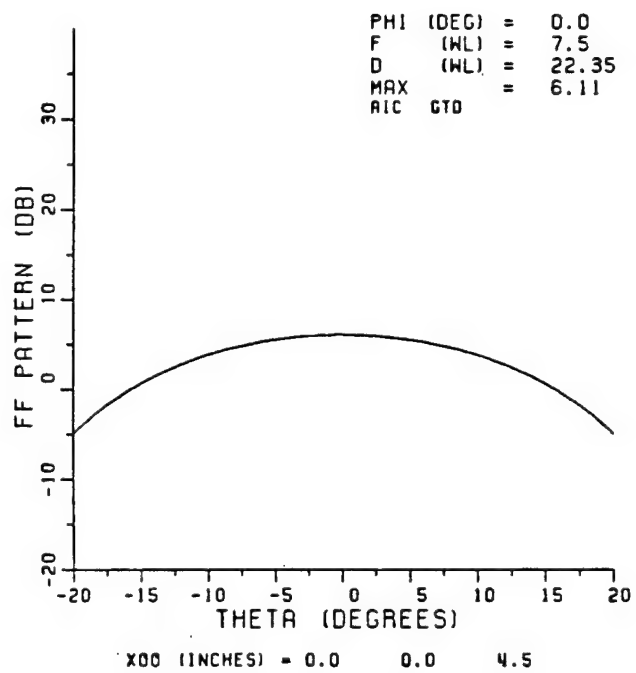


(a) total fields



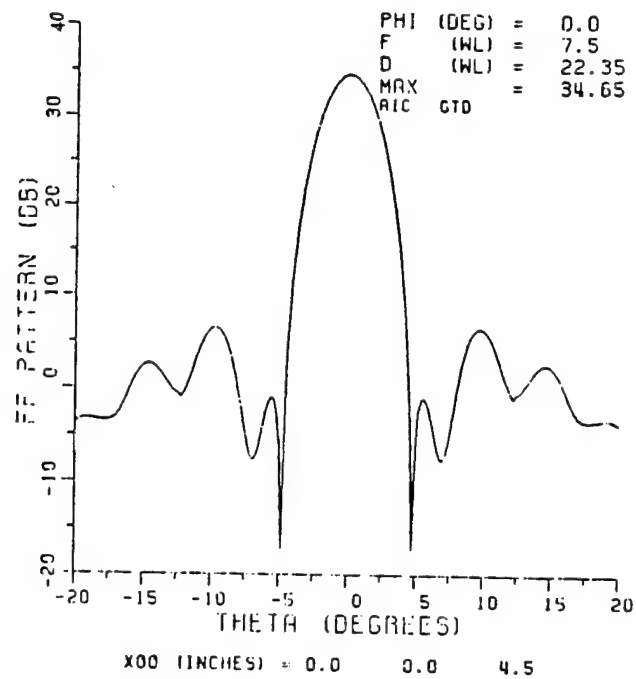
(b) reflector fields

Figure 3. Principal patterns of the circular reflector with a square feed blockage model. (From FB: command).

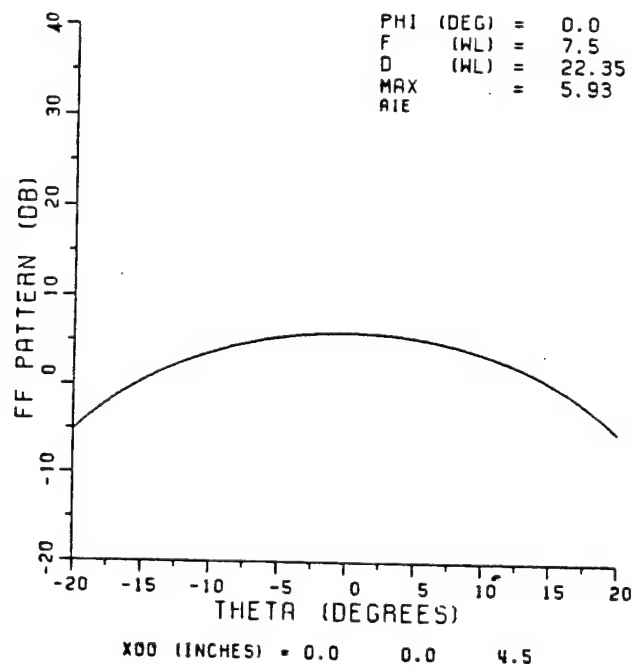


(c) feed blockage (from FB:)

Figure 3. (Continued)



(a) total fields



(b) feed blockage (From AD:)

Figure 4. Principal patterns of the circular reflector with a square plate as the feed blockage model. (From AD: command)

TABLE 4

INPUT DATA FOR THE CALCULATION OF FEED BLOCKAGE BY AIE

```

CM:          ***** C24FBAD.DAT *****
CM: EXAMPLE OF EXTENDED APERTURE INTEGRATION
CE:          FEED BLOCKAGE MODEL (LAD)
DG:          DEFAULT REFLECTOR
1
3  8.0  0.1  0.1  24.  0
TO: AIE ONLY
F  30.  1.
F  0  0  0  0
F  F  F  F  0
T  T  F  0.8
F  F  F  F  F  0.  0.
F  F  0.  0.
AD:
T  F          DIFFRACTED FIELD INCLUDED
8.0
4
-1.2 -1.2
 1.2 -1.2
 1.2  1.2
-1.2  1.2
NF:
0. 0. 4.5      PHASE REFERNECE POINT
F
F
PZ:
1
0.
-20.  20.  0.2
F
PP:
1
1  1
1  2
XQ:

```


TABLE 5

INPUT DATA FOR THE CALCULATION OF FEED BLOCKAGE BY FB: COMMAND

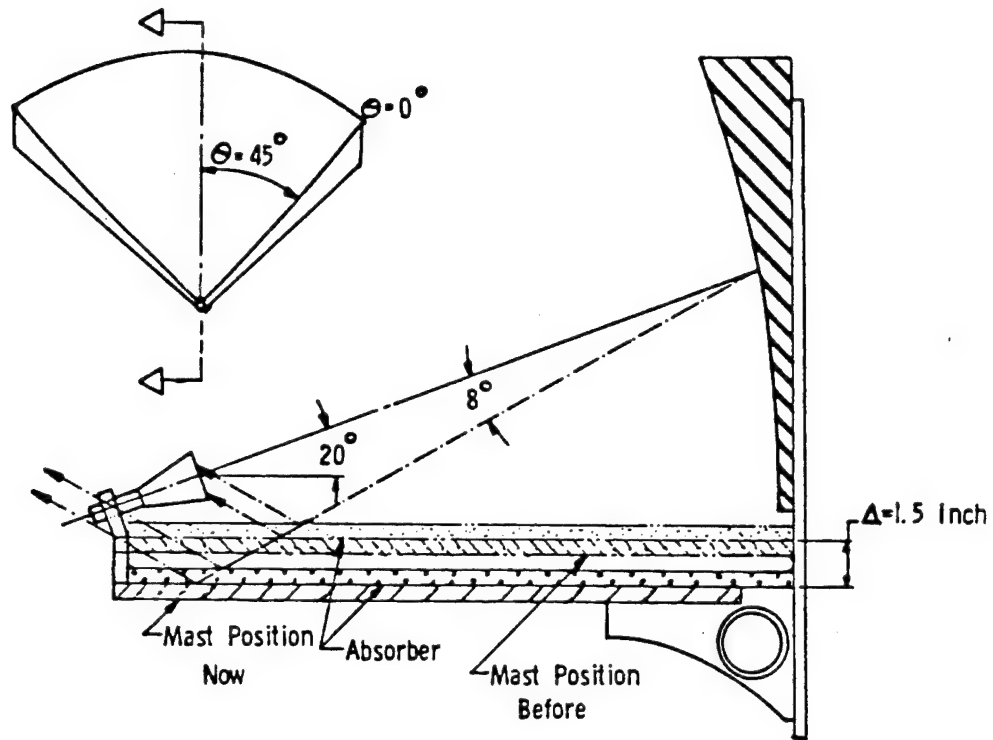
```

CM:          ***** C24FB.DAT *****
CM: EXAMPLE OF EXTENDED APERTURE INTEGRATION
CE:          FEED BLOCKAGE MODEL (FB)
DG:          DEFAULT REFLECTOR
1
3  8.0  0.6  0.6  24.  0
TO: AIE ONLY
F  30.  1.
F  0    0    0    0
F  F    F    F    0
T  T    F    0.8
T  F    F    F    T    F    0.  0.
T  T    0.  0.
FB:
2  0.  0.  8.0          ! RECTANGULAR FEED BLOCKAGE
2.4  2.4
NF:
0.  0.  4.5          PHASE REFERNECE POINT
F
F
PZ:
1
0.
-20.  20.  0.2
F
PP:
3
1  1
1  2
2  1
1  2
3  1
1  2
XQ:

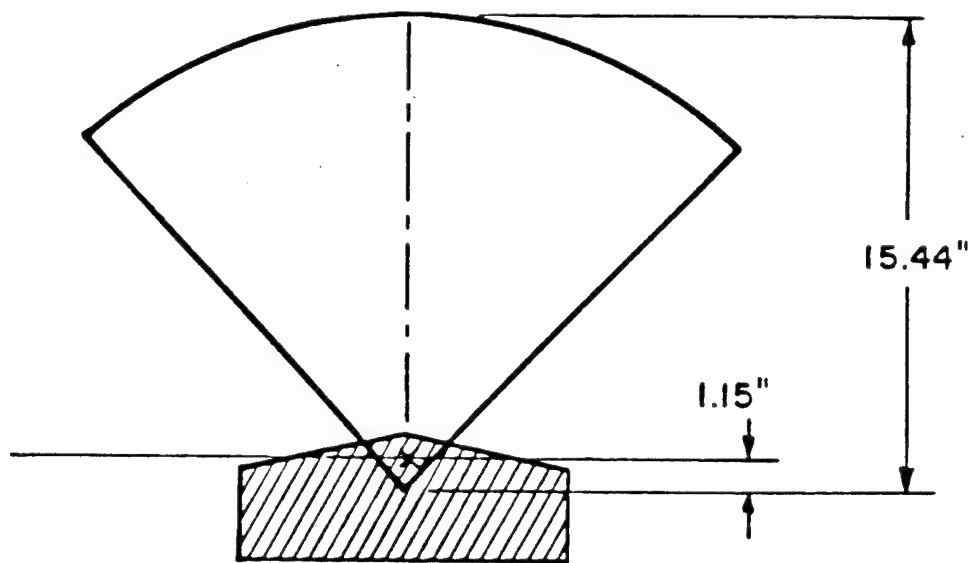
```

Example 3:

This example illustrates the feed/plate scattering model for an offset pi-shaped reflector antenna. The geometry of this antenna with feed mast is given in Figure 5(a). The equivalent plate scatterer is shown in the Figure 5(b). The FB: Command model for feed blockage cannot be used in this example because most of the feed and mast are located outside the G0 region of the reflector as shown in Figure 6. In order to calculate the field from this scatterer, the Extended Aperture Integration has to be used. The aperture field is calculated from the edge diffracted field of the reflector. The input data for calculating the feed scatter is given in Table 6 with the AD: Command used to specify the plate scatterer. The calculated E-plane (offset plane) scattered field at 35 GHz is given in Figure 7. The reflector pattern without the plate is calculated by using the same data as given in Table 6 but without the AD: Command and is shown in Figure 8. The total field is then calculated by subtracting the scattered field from the reflector field (by using FDSCAT23.FOR) and is shown in Figure 9. Note that in the calculations, a common phase center is input in the NF: Command. The measured E-plane pattern is shown in Figure 10. Comparing Figures 8, 9 and 10, it is found the agreement between calculated and measured patterns for $-10^\circ < \theta < 0^\circ$ is improved after the feed scattering effect is included. The differences for $0^\circ < \theta < 10^\circ$ are probably due to the fact that reflections from the feed mast are not modeled in the calculation.



(a) Antenna with feed mast

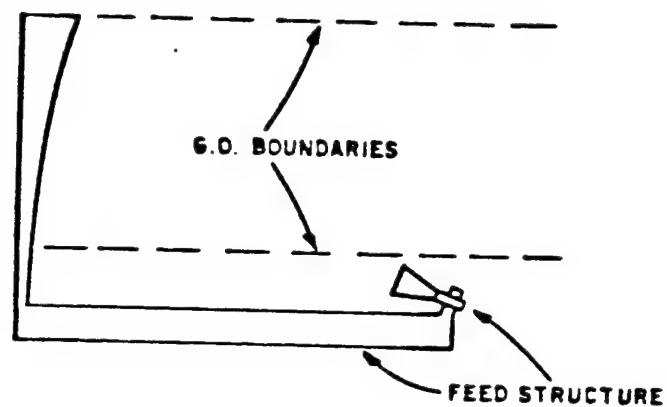


$$f = 35.0 \text{ GHz}$$

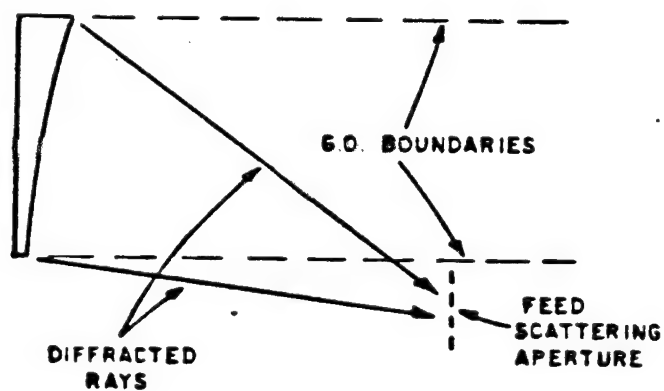
$$F = 20.3'' = 60.16\lambda$$

(b) Equivalent plate scatterer

Figure 5. Equivalent plate scatterer for the feed and mast.



(a) Offset feed structure



(b) Feed scattering aperture

Figure 6. Geometry of feed scattering for offset reflector.

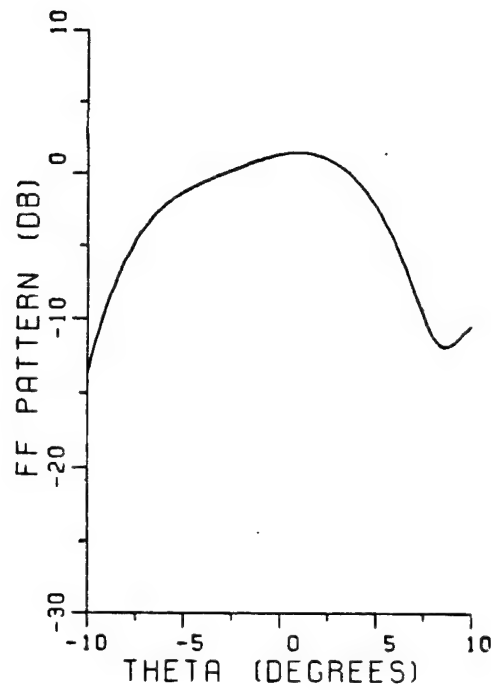


Figure 7. Scattered field from feed scatter by the AD: Command of Example 3 at 35 GHz.

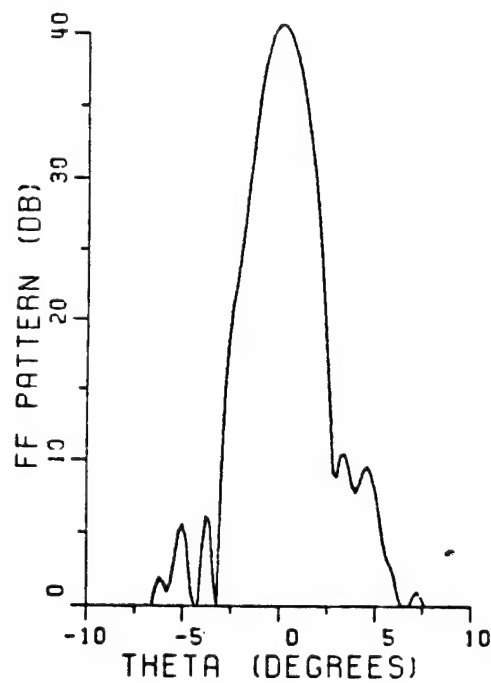


Figure 8. Reflector field for the offset reflector of Example 3 at 35 GHz.

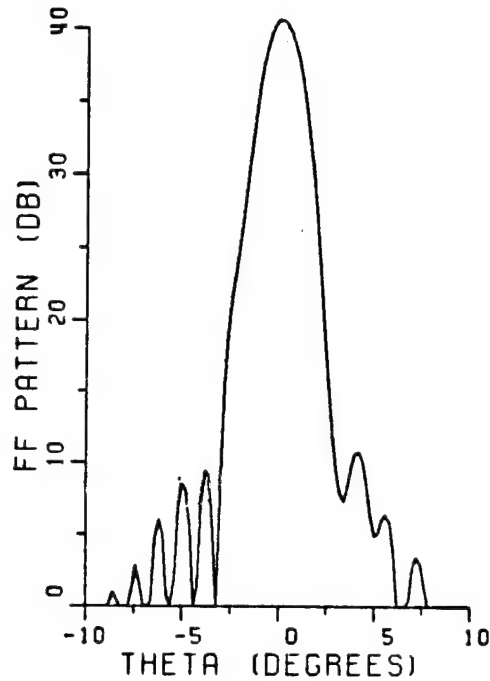


Figure 9. Calculated total field of the offset reflector at 35 GHz.

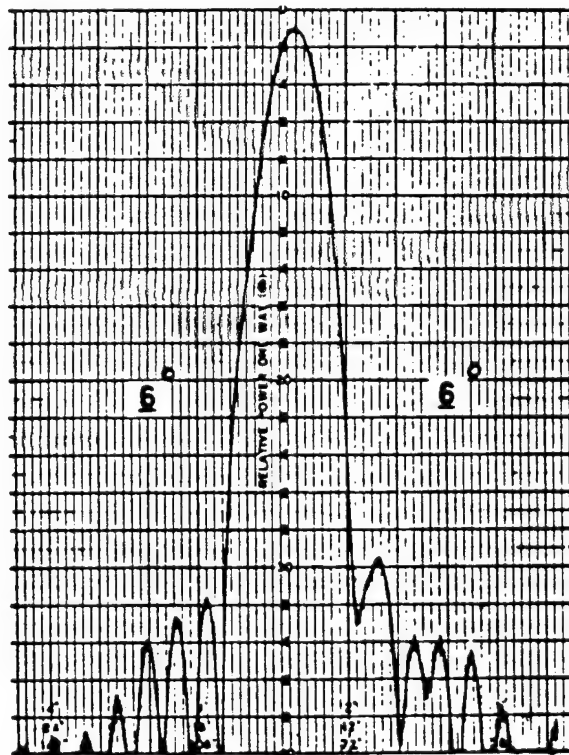


Figure 10. Measured E-plane (offset plane) pattern of the pi-shaped reflector at 35 GHz.

TABLE 6

INPUT DATA FOR SCATTERED FIELD CALCULATION OF EXAMPLE 3

```

CM: ***** LARC35A.DAT *****
CM: USE AD: TO MODIFY THE FEED BLOCKAGE
CM: FEED BLOCKAGE
CE: PI-SHAPED REFLECTOR
DG:
1
3 20.3 0.35 0.35 0. 20
10.66 9.51
9.19 10.95
8.20 11.71
7.15 12.38
6.04 12.95
4.89 13.43
3.70 13.80
2.48 14.07
1.25 14.24
0.00 14.29
-1.25 14.24
-2.48 14.07
-3.70 13.80
-4.89 13.43
-6.04 12.95
-7.15 12.38
-8.20 11.71
-9.19 10.95
-10.66 9.51
0.00 -1.15
AD:
T F
20.3
5
-5.33 -3.00
5.33 -3.00
5.33 -0.22
0.00 1.00
-5.33 -0.22
NF:
0. 6.57 2.517
F
F
TO: LAIC - T ONLY
F 0. 0.
F 0 0 0 0
F F F F 0
T T F F 0.8
T F F F F F 0. 0.
F F 0. 0.
FD:
0 T
T 0 T 1 0. 0. F
2 0. 90.
37
0.000 10.170 55.306 -300. 0.
2.500 9.970 55.603 -300. 0.
5.000 9.383 56.521 -300. 0.
7.500 8.385 58.155 -300. 0.
10.000 6.962 60.691 -300. 0.
12.500 5.085 64.461 -300. 0.
15.000 2.722 70.061 -300. 0.
17.500 -0.143 78.571 -300. 0.
20.000 -3.431 91.869 -300. 0.
22.500 -6.730 112.309 -300. 0.
25.000 -9.125 138.960 -300. 0.
27.500 -10.240 164.140 -300. 0.

```

TABLE 6 - CONTINUED

30.000	-10.944	-177.104	-300.	0.
32.500	-12.007	-163.192	-300.	0.
35.000	-13.714	-151.218	-300.	0.
37.500	-16.149	-138.470	-300.	0.
40.000	-19.267	-121.546	-300.	0.
42.500	-22.539	-95.571	-300.	0.
45.000	-24.314	-60.728	-300.	0.
47.500	-24.028	-31.179	-300.	0.
50.000	-23.365	-12.571	-300.	0.
52.500	-23.178	-0.557	-300.	0.
55.000	-23.563	8.303	-300.	0.
57.500	-24.455	15.829	-300.	0.
60.000	-25.785	23.110	-300.	0.
62.500	-27.488	31.013	-300.	0.
65.000	-29.489	40.446	-300.	0.
67.500	-31.653	52.463	-300.	0.
70.000	-33.711	67.960	-300.	0.
72.500	-35.241	86.490	-300.	0.
75.000	-35.945	105.186	-300.	0.
77.500	-35.977	120.718	-300.	0.
80.000	-35.724	131.981	-300.	0.
82.500	-35.459	139.564	-300.	0.
85.000	-35.296	144.353	-300.	0.
87.500	-35.270	146.990	-300.	0.
90.000	-35.388	147.833	-300.	0.
0.000	10.130	55.523	-300.	0.
2.500	9.838	56.168	-300.	0.
5.000	8.948	58.232	-300.	0.
7.500	7.430	62.170	-300.	0.
10.000	5.243	68.999	-300.	0.
12.500	2.405	80.817	-300.	0.
15.000	-0.718	101.166	-300.	0.
17.500	-2.886	130.712	-300.	0.
20.000	-3.319	158.777	-300.	0.
22.500	-3.311	177.876	-300.	0.
25.000	-3.924	-169.135	-300.	0.
27.500	-5.495	-158.320	-300.	0.
30.000	-8.202	-146.131	-300.	0.
32.500	-12.191	-126.457	-300.	0.
35.000	-16.183	-85.910	-300.	0.
37.500	-15.580	-37.846	-300.	0.
40.000	-13.416	-13.549	-300.	0.
42.500	-12.388	-1.306	-300.	0.
45.000	-12.484	6.765	-300.	0.
47.500	-13.541	13.624	-300.	0.
50.000	-15.526	21.090	-300.	0.
52.500	-18.541	31.666	-300.	0.
55.000	-22.682	51.670	-300.	0.
57.500	-26.146	94.642	-300.	0.
60.000	-24.543	139.284	-300.	0.
62.500	-21.824	159.975	-300.	0.
65.000	-20.013	169.901	-300.	0.
67.500	-19.031	175.716	-300.	0.
70.000	-18.539	179.637	-300.	0.
72.500	-18.397	-177.467	-300.	0.
75.000	-18.490	-175.205	-300.	0.
77.500	-18.732	-173.387	-300.	0.
80.000	-19.056	-171.926	-300.	0.
82.500	-19.408	-170.784	-300.	0.
85.000	-19.745	-169.957	-300.	0.
87.500	-20.036	-169.453	-300.	0.
90.000	-20.261	-169.284	-300.	0.
FQ:				
1	35.			
TL:				
20.0	0.			

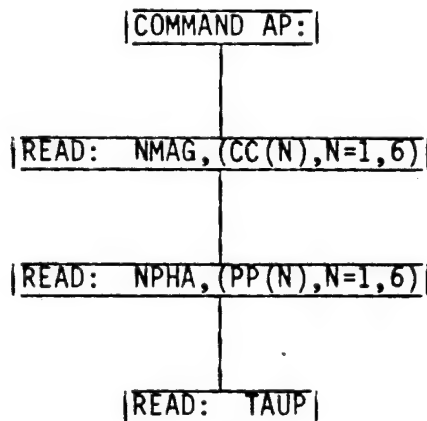
TABLE 6 - CONTINUED

PZ:
1
-90.
-10. 10. 0.2
F
PP:
1
1 1
1 2
XQ:

COMMAND AP: INPUT APERTURE FIELD

This command enables the user to directly input the aperture field distribution without using a feed pattern (FD: Command). The aperture shape is controlled by the DG: Command. Several types of magnitude distributions and phase distributions are available to use. See tables below. If necessary, other distributions can be added as desired in subroutine EAP. Note that if AP: command is used, the input from the FD: Command will be ignored.

BLOCK DIAGRAM FOR APERTURE FIELD INPUT



1. READ: NMAG,(CC(N),N=1,6)

- a) NMAG: This integer variable specifies which type of magnitude distribution is to be used. Several types of magnitude distribution are available as shown below:

NMAG	MAGNITUDE DISTRIBUTION
1	Uniform magnitude
2	Linear variation in X direction: CC(1) dB taper.
3	Linear variation in Y direction: CC(1) dB taper.
4	Linear variation in RHO direction: CC(1) dB taper. (Circular aperture only)
5	Quadratic in X direction: $1+CC(1)X_n+CC(2)X_n^2$
6	Quadratic in Y direction: $1+CC(1)Y_n+CC(2)Y_n^2$
7	Quadratic in RHO direct.: $1+CC(1)R_n+CC(2)R_n^2$ (Circular aperture only)
10	Rectangular wave guide TE ₁₀ mode
11	Circular wave guide TE ₁₁ mode
12	Circular wave guide TM ₁₁ mode
13	Circular wave guide TE ₁₁ and TM ₁₁ mode. The field is defined as $E_{TM11}/E_{TE11}=CC(1)e^{jCC(2)}$
14	Circular waveguide HE ₁₁ mode.
20	see below

The aperture fields of circular waveguide TE₁₁ and TM₁₁ modes have been normalized so that the power carried by each mode is unity.

For NMAG=20, the aperture field in dB is defined as follows:

$$EAP_{dB} = -a_1 \left(\frac{\rho}{\rho_1} \right)^2 \quad 0 < \rho < \rho_1$$

$$EAP_{dB} = -a_1 \left(\frac{\rho}{\rho_1} \right)^2 - \left(a_2 - \frac{a_1}{\rho_1^2} \right) \left(\frac{\rho - \rho_1}{1 - \rho_1} \right)^2 \quad \rho_1 < \rho < 1$$

where ρ is the normalized radial distance from aperture center, and a_1 and a_2 specify the aperture field in dB at ρ_1 and 1, respectively. Thus, the aperture field is $-a_1$ dB at $\rho = \rho_1$ and is $-a_2$ dB at $\rho = 1$. a_1 , ρ_1 and a_2 are input in CC(1), CC(2), and CC(3), respectively.

- b) CC(N): This dimensioned real variable is used to supply the necessary constants for the magnitude distribution.
 NOTE: X_n , Y_n , and R_n in the above table are normalized quantities as measured from the center (X_o, Y_o) of the aperture where $X_o = 0.5 (X_{max} + X_{min})$ and $Y_o = 0.5 (Y_{max} + Y_{min})$. For example, NMAG=5, CC(1)=0 and CC(2)=-0.8 gives an aperture distribution that has a -14 dB edge illumination along the X direction. A circular aperture that goes to zero at the rim can be obtained by using D>0 in the DG: Command and NMAG=7, CC(1)=0 and CC(2)=-1. When NMAG=13, CC(1) and CC(2) define the field ratio between TM_{11} and TE_{11} modes as shown in the table where CC(1) is the magnitude and CC(2) is the phase shift in degrees.

When NMAG=11 and the radius of the waveguide is smaller than the cutoff radius of the TE_{11} mode, CC(1)=1 specifies that normalization constant of the waveguide mode is ignored so that one can still use AP: Command to simulate elements of microstrip antenna.

Currently, only the first two constants are used at most, but an array dimension of 6 is reserved for future use. Note that 6 values must be input the CC(N), although only one or two are used.

2. READ: NPHA,(PP(N),N=1,6)

- a) NPHA: This integer variable specifies the type of phase distribution to be used. Several types of phase distribution are available as shown below:

NPHA	PHASE DISTRIBUTION
1	Constant phase of PP(1) degrees.
2	Phase for beam scanned PP(1) degrees in X direction.
3	Phase for beam scanned PP(1) degrees in Y direction.
4	Phase for beam scanned PP(1) degrees in the Theta direction (from Z-axis) and PP(2) degrees in the PHI direction (from XY plane).
10	Rectangular horn phase with horn flare angles: PP(1), PP(2) degrees in X and Y, respectively.
11	Conical horn phase with horn flare angle: PP(1) degrees.

- b) PP(N): This dimensioned real variable is used to supply the necessary constants for phase distribution. Similar to CC(N), at most 2 out of 6 are currently used.

3. READ: TAUP

- a) TAUP: This real variable is input in degrees and defines the linear polarization angle of the aperture field.

Example 1: This example illustrates the use of the AP: Command to calculate the radiation patterns of a conical horn antenna. This horn antenna has diameter of 1.2" and flare angle of 14.9 degrees and is operated at 38 GHz. The input data are given in Table 1 and the patterns of this horn are given in Figure 1. Note also that LFDOUT in the PZ: Command is true so the output patterns are stored in Unit #7 which is given in Table 2, and can be used as linear feed input in the FD: Command of other runs such as the examples in the DG: Command.

TABLE 1

INPUT DATA FOR CONICAL HORN PATTERN CALCULATION

```

CM:          ***** CONI.DAT *****
CM:  USE AP: TO GENERATE CONICAL HORN PATTERNS
CM:  CONICAL HORN, : 1.2" DIAMETER, 14.9 DEG. FLARE
CE:          38.0 GHZ
DG:
1
3      2.    0.02    0.02    1.2    0
AP:
11      0.      0.      0.      0.      0.      0.
11      14.9    0.      0.      0.      0.      0.
90.
FQ:
1      38.
PZ:
3
0.      45.      90.
0.      90.      1.
T
PP:
1
1      1
1      2
XQ:

```

TABLE 2

OUTPUT DATA FROM UNIT #7 OF THE CONICAL HORN PATTERNS

0.000	35.510	71.481	-47.871	-110.173
1.000	35.478	71.505	-47.992	-111.291
2.000	35.383	71.578	-48.288	-112.285
3.000	35.223	71.701	-48.770	-113.173
4.000	34.999	71.875	-49.454	-113.969
5.000	34.710	72.104	-50.369	-114.681
6.000	34.354	72.392	-51.558	-115.314
7.000	33.929	72.744	-53.093	-115.860
8.000	33.435	73.165	-55.099	-116.303
9.000	32.869	73.665	-57.822	-116.590
10.000	32.229	74.255	-61.850	-116.530
11.000	31.510	74.947	-69.377	-114.909
12.000	30.710	75.760	-79.011	50.127
13.000	29.824	76.716	-65.522	58.389
14.000	28.845	77.846	-60.826	59.005
15.000	27.768	79.191	-58.113	59.058
16.000	26.584	80.805	-56.342	58.974
17.000	25.283	82.765	-55.146	58.856
18.000	23.853	85.183	-54.355	58.748
19.000	22.282	88.218	-53.878	58.670
20.000	20.555	92.112	-53.661	58.641
21.000	18.662	97.235	-53.672	58.679
22.000	16.609	104.154	-53.894	58.805
23.000	14.446	113.694	-54.318	59.046
24.000	12.330	126.825	-54.945	59.441
25.000	10.596	143.883	-55.782	60.050
26.000	9.629	163.071	-56.848	60.962
27.000	9.473	-179.206	-58.172	62.328
28.000	9.766	-165.194	-59.802	64.410
29.000	10.142	-154.821	-61.812	67.710
30.000	10.411	-147.137	-64.313	73.294
31.000	10.504	-141.259	-67.429	83.703
32.000	10.406	-136.563	-70.952	105.147
33.000	10.117	-132.626	-72.735	143.072
34.000	9.643	-129.158	-70.954	175.949
35.000	8.988	-125.941	-68.502	-167.552
36.000	8.150	-122.795	-66.632	-159.442
37.000	7.125	-119.542	-65.340	-155.083
38.000	5.899	-115.981	-64.498	-152.624
39.000	4.455	-111.840	-64.010	-151.273
40.000	2.766	-106.706	-63.813	-150.652
41.000	0.809	-99.895	-63.869	-150.579
42.000	-1.414	-90.215	-64.154	-150.973
43.000	-3.774	-75.700	-64.660	-151.822
44.000	-5.757	-54.353	-65.386	-153.173
45.000	-6.452	-28.471	-66.343	-155.146
46.000	-5.730	-5.947	-67.552	-157.969
47.000	-4.471	9.599	-69.045	-162.059
48.000	-3.281	19.812	-70.859	-168.201
49.000	-2.333	26.781	-73.001	-177.903
50.000	-1.637	31.815	-75.292	166.150
51.000	-1.162	35.652	-76.946	141.521
52.000	-0.878	38.717	-76.788	113.449
53.000	-0.756	41.267	-75.205	92.215
54.000	-0.775	43.467	-73.386	79.027
55.000	-0.919	45.425	-71.810	70.819
56.000	-1.175	47.221	-70.540	65.393
57.000	-1.533	48.913	-69.539	61.577
58.000	-1.986	50.549	-68.760	58.748
59.000	-2.527	52.170	-68.164	56.560
60.000	-3.154	53.814	-67.719	54.806

TABLE 2 - CONTINUED

61.000	-3.864	55.521	-67.402	53.360
62.000	-4.656	57.331	-67.193	52.138
63.000	-5.530	59.293	-67.077	51.083
64.000	-6.486	61.466	-67.043	50.156
65.000	-7.527	63.924	-67.081	49.330
66.000	-8.654	66.765	-67.181	48.582
67.000	-9.870	70.116	-67.338	47.898
68.000	-11.172	74.154	-67.543	47.266
69.000	-12.556	79.116	-67.793	46.677
70.000	-14.002	85.311	-68.081	46.123
71.000	-15.467	93.116	-68.403	45.600
72.000	-16.864	102.886	-68.754	45.102
73.000	-18.053	114.718	-69.130	44.627
74.000	-18.870	128.088	-69.526	44.171
75.000	-19.213	141.735	-69.940	43.734
76.000	-19.126	154.224	-70.365	43.314
77.000	-18.760	164.709	-70.798	42.911
78.000	-18.269	173.073	-71.235	42.524
79.000	-17.759	179.604	-71.672	42.156
80.000	-17.286	-175.316	-72.104	41.806
81.000	-16.876	-171.351	-72.526	41.477
82.000	-16.537	-168.239	-72.935	41.172
83.000	-16.268	-165.788	-73.326	40.892
84.000	-16.067	-163.860	-73.695	40.640
85.000	-15.929	-162.354	-74.038	40.420
86.000	-15.850	-161.200	-74.352	40.235
87.000	-15.827	-160.348	-74.633	40.088
88.000	-15.855	-159.761	-74.879	39.981
89.000	-15.934	-159.418	-75.088	39.916
90.000	-300.000	0.000	-300.000	0.000
0.000	35.507	71.502	-36.325	40.356
1.000	35.467	71.541	-22.513	53.085
2.000	35.346	71.659	-11.934	55.588
3.000	35.143	71.858	-5.298	56.211
4.000	34.858	72.144	-0.580	56.482
5.000	34.488	72.522	3.020	56.656
6.000	34.032	73.004	5.879	56.795
7.000	33.486	73.601	8.206	56.925
8.000	32.847	74.333	10.126	57.058
9.000	32.110	75.222	11.721	57.200
10.000	31.270	76.300	13.047	57.357
11.000	30.319	77.610	14.143	57.531
12.000	29.249	79.210	15.037	57.726
13.000	28.050	81.185	15.751	57.945
14.000	26.711	83.653	16.300	58.192
15.000	25.216	86.791	16.696	58.472
16.000	23.554	90.862	16.948	58.790
17.000	21.716	96.272	17.060	59.153
18.000	19.716	103.636	17.037	59.569
19.000	17.619	113.819	16.880	60.050
20.000	15.619	127.724	16.588	60.611
21.000	14.075	145.315	16.157	61.271
22.000	13.322	164.272	15.582	62.058
23.000	13.293	-178.889	14.852	63.010
24.000	13.600	-165.822	13.953	64.185
25.000	13.917	-156.151	12.866	65.669
26.000	14.084	-148.917	11.559	67.602
27.000	14.045	-143.297	9.991	70.222
28.000	13.784	-138.708	8.099	73.965
29.000	13.296	-134.746	5.792	79.707
30.000	12.578	-131.107	2.972	89.397
31.000	11.617	-127.528	-0.270	107.537
32.000	10.394	-123.735	-2.622	140.162
33.000	8.875	-119.365	-1.819	175.584
34.000	7.007	-113.836	0.482	-163.245
35.000	4.722	-106.068	2.492	-152.051

TABLE 2 - CONTINUED

36.000	1.989	-93.822	3.975	-145.513
37.000	-0.894	-72.747	5.018	-141.256
38.000	-2.467	-40.362	5.716	-138.231
39.000	-1.475	-9.630	6.137	-135.923
40.000	0.472	9.305	6.325	-134.055
41.000	2.168	20.221	6.312	-132.460
42.000	3.425	27.061	6.115	-131.029
43.000	4.297	31.765	5.746	-129.682
44.000	4.855	35.257	5.210	-128.355
45.000	5.155	38.018	4.506	-126.982
46.000	5.234	40.321	3.624	-125.493
47.000	5.120	42.333	2.550	-123.795
48.000	4.830	44.171	1.255	-121.751
49.000	4.372	45.921	-0.301	-119.137
50.000	3.752	47.661	-2.185	-115.548
51.000	2.967	49.465	-4.499	-110.158
52.000	2.009	51.423	-7.384	-101.055
53.000	0.862	53.654	-10.859	-83.333
54.000	-0.499	56.332	-13.583	-48.296
55.000	-2.113	59.746	-12.465	-8.751
56.000	-4.037	64.413	-9.642	13.079
57.000	-6.344	71.360	-7.266	23.881
58.000	-9.085	82.782	-5.484	29.978
59.000	-11.995	103.163	-4.149	33.857
60.000	-13.591	135.658	-3.140	36.550
61.000	-12.441	166.940	-2.377	38.544
62.000	-10.236	-174.167	-1.805	40.093
63.000	-8.264	-163.596	-1.384	41.343
64.000	-6.708	-157.174	-1.088	42.382
65.000	-5.503	-152.912	-0.895	43.268
66.000	-4.569	-149.877	-0.790	44.040
67.000	-3.845	-147.597	-0.758	44.725
68.000	-3.286	-145.813	-0.791	45.341
69.000	-2.860	-144.371	-0.879	45.903
70.000	-2.541	-143.177	-1.014	46.422
71.000	-2.312	-142.166	-1.190	46.905
72.000	-2.157	-141.297	-1.401	47.359
73.000	-2.064	-140.540	-1.642	47.787
74.000	-2.024	-139.874	-1.908	48.194
75.000	-2.028	-139.282	-2.193	48.581
76.000	-2.069	-138.754	-2.495	48.951
77.000	-2.141	-138.281	-2.808	49.303
78.000	-2.238	-137.856	-3.129	49.638
79.000	-2.356	-137.474	-3.453	49.956
80.000	-2.490	-137.132	-3.777	50.255
81.000	-2.637	-136.827	-4.098	50.535
82.000	-2.794	-136.557	-4.411	50.794
83.000	-2.956	-136.320	-4.714	51.029
84.000	-3.123	-136.116	-5.004	51.239
85.000	-3.291	-135.944	-5.277	51.422
86.000	-3.459	-135.804	-5.532	51.575
87.000	-3.625	-135.694	-5.765	51.696
88.000	-3.787	-135.616	-5.977	51.784
89.000	-3.946	-135.570	-6.165	51.837
90.000	-300.000	0.000	-300.000	0.000
0.000	35.505	71.492	-111.111	90.176
1.000	35.457	71.546	-64.215	-25.526
2.000	35.310	71.710	-58.300	-25.574
3.000	35.063	71.990	-54.967	-25.497
4.000	34.716	72.395	-52.736	-25.350
5.000	34.263	72.939	-51.145	-25.141
6.000	33.700	73.645	-49.991	-24.870
7.000	33.022	74.541	-49.167	-24.529
8.000	32.221	75.670	-48.609	-24.111
9.000	31.287	77.092	-48.281	-23.603
10.000	30.207	78.893	-48.159	-22.990

TABLE 2 - CONTINUED

11.000	28.967	81.203	-48.229	-22.248
12.000	27.547	84.218	-48.485	-21.346
13.000	25.927	88.251	-48.926	-20.241
14.000	24.089	93.808	-49.558	-18.868
15.000	22.039	101.720	-50.393	-17.133
16.000	19.862	113.259	-51.450	-14.889
17.000	17.851	129.802	-52.757	-11.893
18.000	16.579	150.883	-54.352	-7.732
19.000	16.425	172.085	-56.280	-1.646
20.000	17.022	-171.094	-58.563	7.815
21.000	17.785	-159.214	-61.059	23.310
22.000	18.409	-150.905	-63.042	47.658
23.000	18.797	-144.871	-63.260	76.455
24.000	18.933	-140.255	-61.956	98.783
25.000	18.825	-136.520	-60.388	112.718
26.000	18.480	-133.315	-59.103	121.421
27.000	17.900	-130.390	-58.182	127.249
28.000	17.080	-127.538	-57.594	131.460
29.000	16.001	-124.550	-57.300	134.724
30.000	14.632	-121.158	-57.269	137.425
31.000	12.919	-116.947	-57.482	139.808
32.000	10.779	-111.150	-57.931	142.050
33.000	8.100	-102.114	-58.619	144.302
34.000	4.862	-85.907	-59.561	146.728
35.000	1.980	-55.264	-60.789	149.546
36.000	2.166	-16.369	-62.354	153.102
37.000	4.534	8.582	-64.341	158.048
38.000	6.733	21.528	-66.878	165.799
39.000	8.356	28.943	-70.074	179.873
40.000	9.494	33.741	-73.340	-151.623
41.000	10.255	37.157	-73.632	-109.610
42.000	10.718	39.779	-70.982	-81.348
43.000	10.933	41.917	-68.410	-67.467
44.000	10.936	43.754	-66.484	-59.909
45.000	10.749	45.409	-65.087	-55.195
46.000	10.383	46.967	-64.086	-51.935
47.000	9.846	48.502	-63.389	-49.498
48.000	9.137	50.081	-62.935	-47.564
49.000	8.247	51.782	-62.683	-45.951
50.000	7.163	53.708	-62.606	-44.546
51.000	5.857	56.009	-62.684	-43.275
52.000	4.288	58.929	-62.905	-42.082
53.000	2.393	62.915	-63.260	-40.925
54.000	0.076	68.868	-63.745	-39.764
55.000	-2.780	78.845	-64.359	-38.560
56.000	-6.095	97.817	-65.104	-37.269
57.000	-8.381	132.679	-65.989	-35.835
58.000	-7.156	169.238	-67.025	-34.185
59.000	-4.529	-170.137	-68.229	-32.208
60.000	-2.285	-159.477	-69.630	-29.735
61.000	-0.573	-153.291	-71.267	-26.476
62.000	0.726	-149.285	-73.196	-21.912
63.000	1.717	-146.470	-75.485	-15.012
64.000	2.476	-144.369	-78.172	-3.603
65.000	3.054	-142.727	-80.970	16.578
66.000	3.487	-141.399	-82.454	48.119
67.000	3.803	-140.292	-81.333	78.402
68.000	4.022	-139.349	-79.173	96.998
69.000	4.159	-138.531	-77.201	107.508
70.000	4.228	-137.809	-75.615	113.891
71.000	4.238	-137.164	-74.362	118.101
72.000	4.199	-136.582	-73.369	121.067
73.000	4.118	-136.053	-72.577	123.264
74.000	4.001	-135.568	-71.944	124.954
75.000	3.855	-135.121	-71.437	126.293
76.000	3.684	-134.708	-71.035	127.377

TABLE 2 - CONTINUED

77.000	3.494	-134.326	-70.717	128.270
78.000	3.288	-133.973	-70.472	129.015
79.000	3.071	-133.648	-70.287	129.642
80.000	2.847	-133.349	-70.154	130.173
81.000	2.618	-133.076	-70.065	130.623
82.000	2.389	-132.829	-70.015	131.004
83.000	2.161	-132.609	-69.999	131.326
84.000	1.938	-132.416	-70.013	131.594
85.000	1.723	-132.251	-70.052	131.814
86.000	1.515	-132.115	-70.116	131.990
87.000	1.319	-132.008	-70.201	132.123
88.000	1.134	-131.931	-70.306	132.218
89.000	0.963	-131.885	-70.430	132.274
90.000	-300.000	0.000	-300.000	0.000

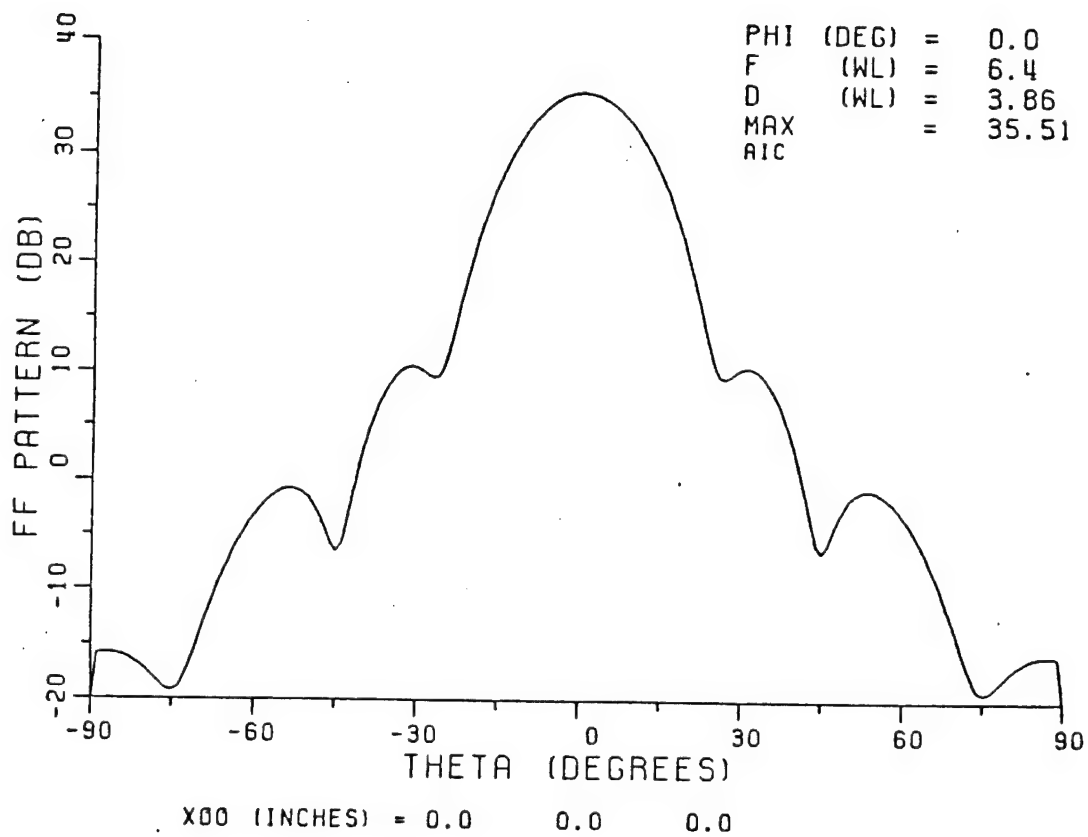


Figure 1(a). H-plane patterns of the 1.2" D conical horn.

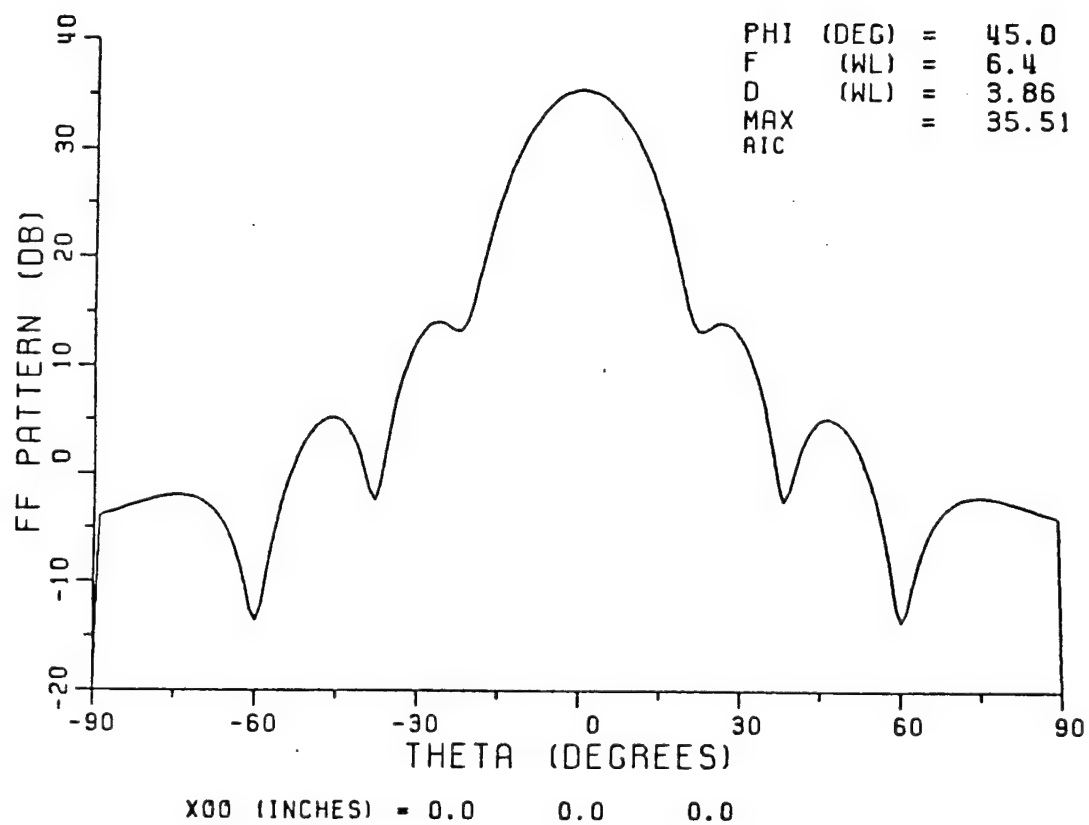


Figure 1(b). 45°-cut pattern of the 1.2" D conical horn.

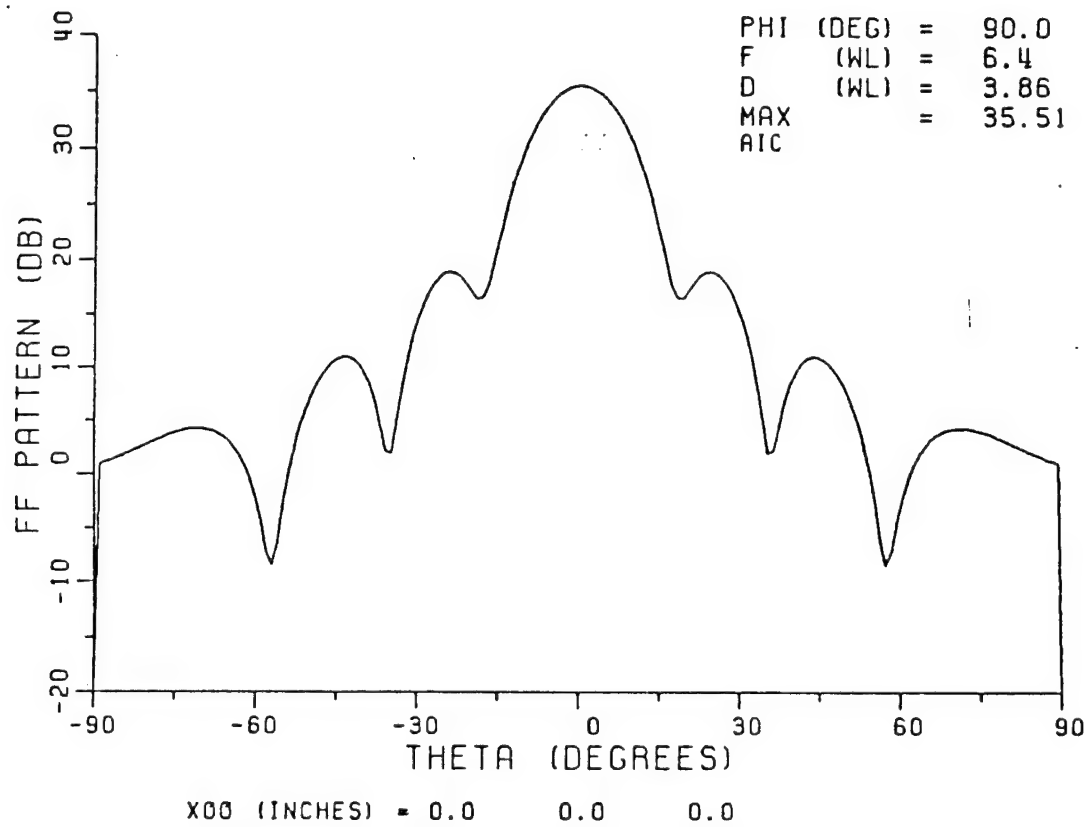
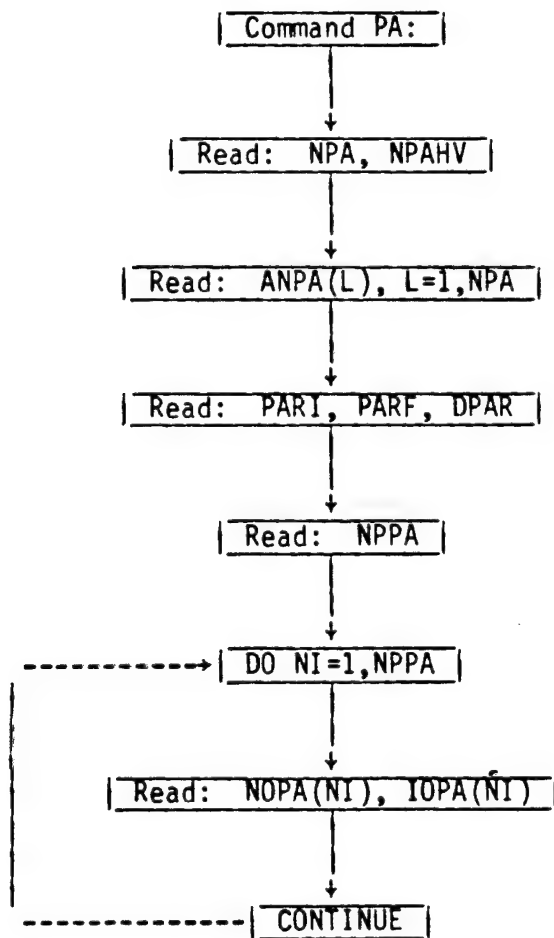


Figure 1(c). E-plane pattern of the 1.2" D conical horn.

Command PA: PLOT APERTURE DISTRIBUTION

This command provides the capability of plotting aperture field distributions which are specified by the AP: Command. All plot data are output on Unit #16.

BLOCK DIAGRAM FOR PLOTS OF APERTURE DISTRIBUTION



1. READ: MPA, MPAHV

- a) NPA: This integer variable specifies the number of cuts across the aperture of the reflector.
- b) NPAHV: This integer variable specifies whether the cuts are horizontal or vertical.

NPAHV=1: horizontal cut
NPAHV=2: vertical cut

2. READ: ANPA(L), L=1, NPA

This read statement is used to specify the location of the cut.

- a) ANPA(L): This real variable specifies the location of the cut. IF NPAHV=1, this variable specifies the y-coordinate (in units) of the cut; if NPAHV=2, this variable specifies the x-coordinate (in units) of the cut.

3. READ: PARI, PARF, DPAR

- a) PARI: This real variable specifies the initial x or y coordinate (in units) of the aperture points along each cut.
- b) PARF: This real variable specifies the final x or y coordinate (in units) of the aperture points along each cut.
- c) DPAR: This real variable specifies the increment (in units) in x or y coordinates of the aperture points along each cut.

4. READ: NPPA

- a) NPPA: This integer variable specifies the number of plots for each cut.

5. READ: NOPA(NI), IOPA(NI)

This statement is executed NPPA times.

a) This integer variable specifies the polarization component to be plotted as follows:

1 : X component of the aperture field

NOPA(NI) =

2 : Y component of the aperture field

b) IOPA(NZ): This integer specifies the format to be plotted as follows:

1 : magnitude of the aperture field

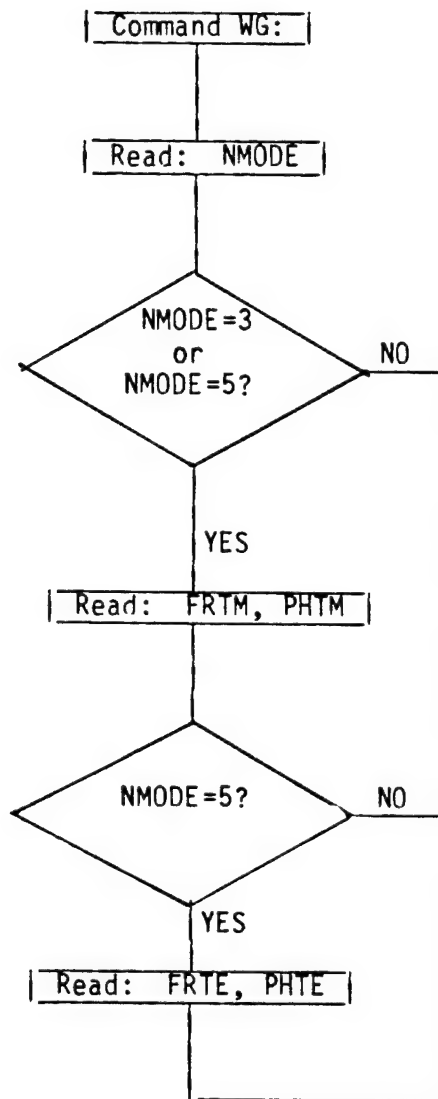
IOPA(NI): 2 : dB value of the aperture field

3 : phase of the aperture field

Command WG: WAVEGUIDE MODE

This command provides an efficient calculation of the radiation patterns of some useful waveguide modes. The analytic radiation field expressions as given in Silver, Microwave Antenna Theory and Design, page 337-338 are used to obtain the patterns. The aperture fields of each waveguide mode have been normalized so that each mode carries unit power.

BLOCK DIAGRAM FOR WG:



1. Read: NMODE

- a) NMODE: This integer variable specifies the type of waveguide mode as follows:

NMODE:	{	1	:	Circular TE ₁₁ mode
		2	:	Circular TM ₁₁ mode
		3	:	Circular TE ₁₁ and TM ₁₁ modes
		4	:	Circular TE ₁₂ mode
		5	:	Circular TE ₁₁ , TM ₁₁ , and TE ₁₂ modes

The field ratios between TM₁₁ and TE₁₁ modes for NMODE=3 or NMODE=5 is specified by the read statement 2 and field ratio between TE₁₂ and TE₁₁ modes for NMODE=5 is given in read statement 3.

2. Read: FRTM, PHTM

This read statement is executed for NMODE=3 or NMODE=5 only.

- a) FRTM: This real variable specifies the magnitude of the field ratio (TM₁₁/TE₁₁).
- b) PHTM: This real variable specifies the phase shift (in degrees) of the TM₁₁ mode from the TE₁₁ mode.

The complex field ratio is thus specified as

$$\frac{E_{TM_{11}}}{E_{TE_{11}}} = FRTM \cdot e^{j \cdot PHTM}$$

3. Read: FRTE, PHTE

This read statement is executed for NMODE=5 only.

- a) FRTE: This real variable specifies the magnitude of the field ratio between the TE₁₂ and the TE₁₁ modes.
- b) PHTE: This real variable specifies the phase shift (in degrees) of the TE₁₂ mode from the TE₁₁ mode.

Thus, the complex field ratio between the TE₁₂ and the TE₁₁ mode is given as

$$\frac{E_{TE_{12}}}{E_{TE_{11}}} = FRTE \cdot e^{jPHTE}$$

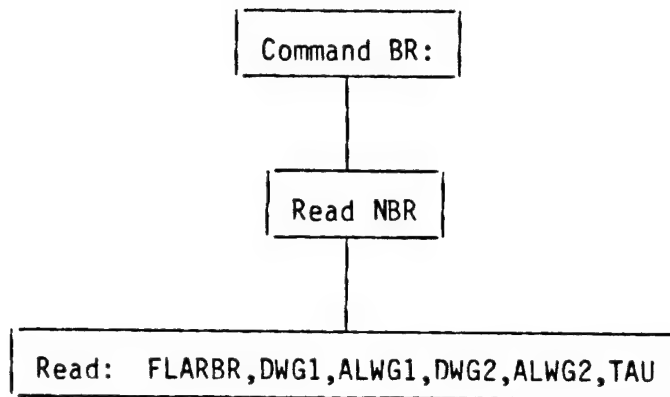
Command BR: BODY OF REVOLUTION (MOMENT METHOD)

This command enables the user to calculate the radiation patterns of circular conical, corrugated and dual mode horn antennas. The geometries of these three horns are shown in Figure 1. The radiation patterns of a circular waveguide can also be calculated by this command. The geometry of the circular waveguide is shown in Figure 2. Moment Method is used to calculate the patterns. The corrugated horn patterns are simulated by the H-plane pattern of conical horn which has the same geometry as the inner dimension of the corrugated horn. The patterns of the corrugated horn are assumed to be circular symmetric.

This command is used similar to the AP: and WG: Commands. one should not use the FD: Command when this command is used. The input dimension is specified by IUNIT in the DG: Command while the other variables in the DG: Command will be ignored. If the DG: Command is not used, the input dimension is in inches.

Although one can also use either the AP: or the WG: Commands to calculate the radiation patterns of these horns, only the BR: Command can be used to generate backlobes of the patterns since aperture integration is used in the AP: and WG: Commands and only gives patterns in the forward region. Also the Aperture Integration is not accurate for small aperture horns. One can also let LFDOUT=true in the PZ: Command to output the patterns from Unit #7.

BLOCK DIAGRAM FOR BR: COMMAND



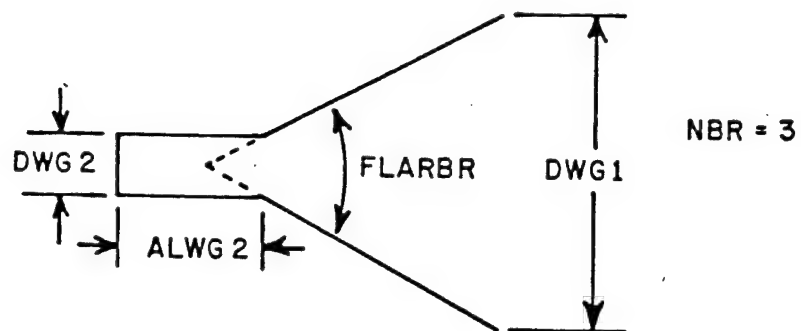
1. Read: NBR

- a) NBR: This integer variable specifies the type of the horn as follows:

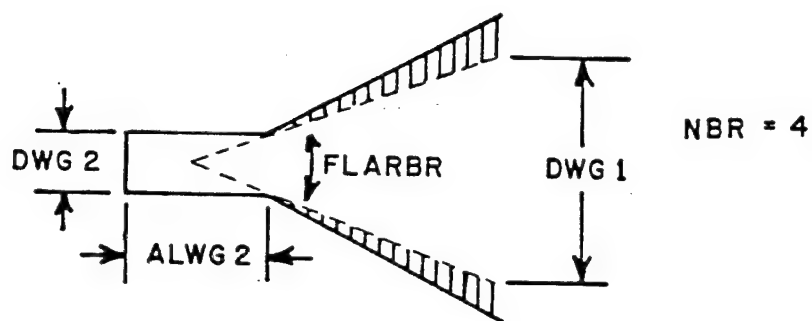
NBR=3 : Conical Horn
NBR=4 : Corrugated Horn
NBR=5 : Dual Mode Horn
NBR=6 : Circular Waveguide

2. Read: FLARBR, DWG1, ALWG1, DWG2, ALWG2, TAU

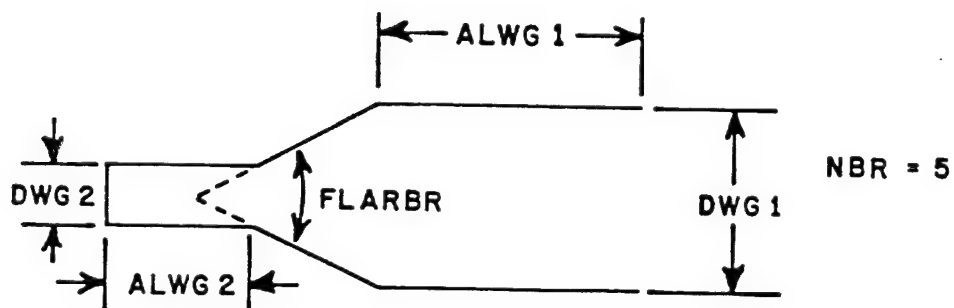
- a) FLARBR: This real variable specifies the full flare angle (in degrees) of the flared section of the horn. Note FLARBR should not be zero. When NBR=6, this variable is ignored.
- b) DWG1: This real variable defines the aperture diameter of the horn. When NBR=6, this variable is ignored.
- c) ALWG1: This real variable specifies the length of the waveguide section of the dual-mode horn where the diameter of the waveguide is DWG1. For conical or corrugated horns, this variable is ignored in the code. When NBR=6, this variable is also ignored.
- d) DWG2: This real variable specifies the diameter of the waveguide which is used to generate the circular waveguide TE_{11} mode. In order to assure that the only waveguide mode propagating is the TE_{11} mode, DWG2 must be small enough so that higher order modes are cut off. On the other hand, DWG2 must be large enough to let the TE_{11} mode propagate. Normally, $0.586\lambda < DWG2 < 1.220\lambda$. A typical number for DWG2 is 0.75λ . For NBR=6, this variable specifies the diameter of the waveguide.
- e) ALWG2: This real variable specifies the waveguide length where the waveguide is used to generate the TE_{11} mode and has diameter DWG2.
- f) TAU: This real variable defines the polarization angle of the horn.



CONICAL HORN



CORRUGATED HORN



DUAL MODE HORN

Figure 1. Geometries of 3 circular symmetric horns.

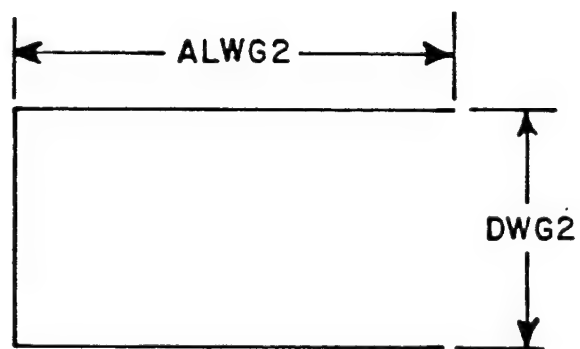
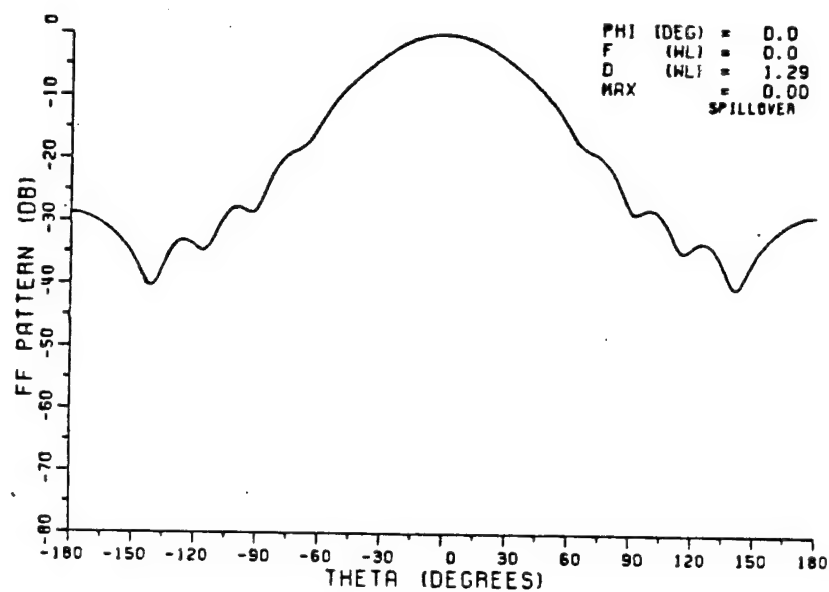


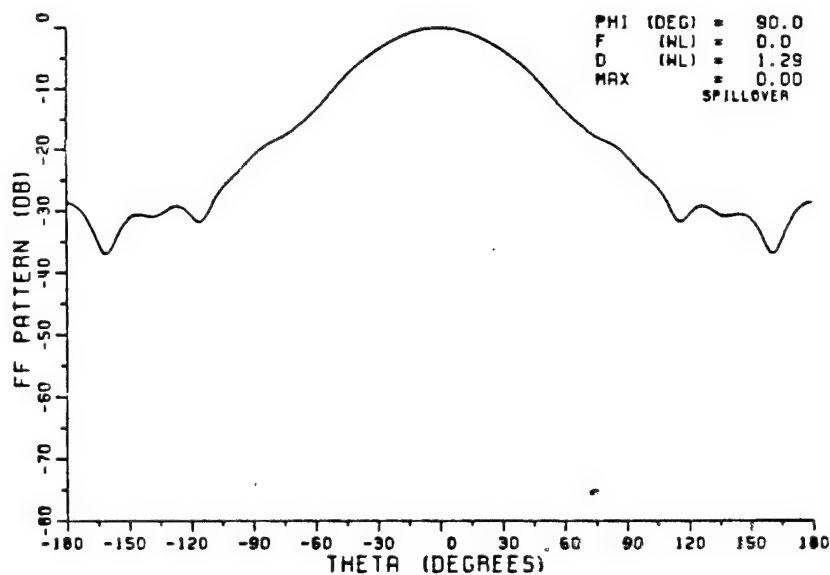
Figure 2. Geometry of a circular waveguide.

Example 1:

In this example, the radiation patterns of a dual-mode horn are calculated by the BR: Command. The frequency is 11.0 GHz. The calculated patterns are given in Figure 3 and the measured patterns are given in Figure 4. Note that the backlobe in the calculation is higher than the measurement because structures for mounting and feeding the horn in the measurement system are not modeled in the calculation. The input data for the calculation are given in Table 1.

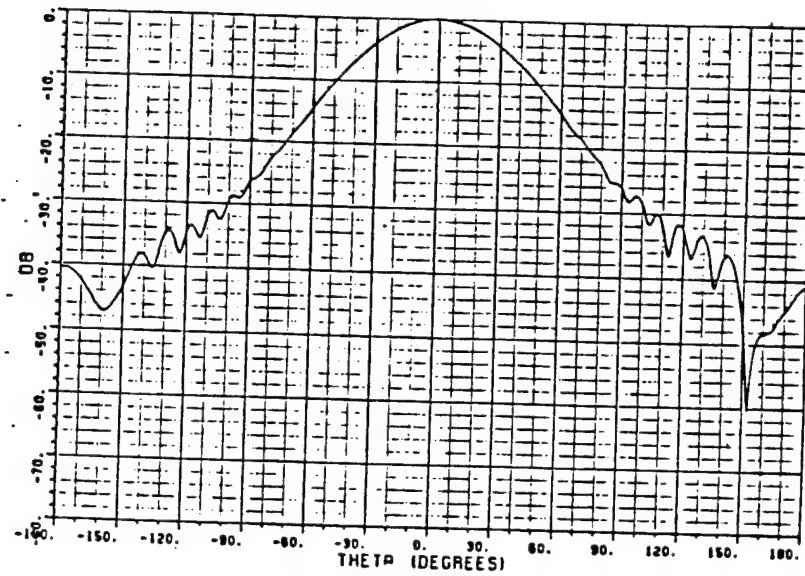


(a) H-plane

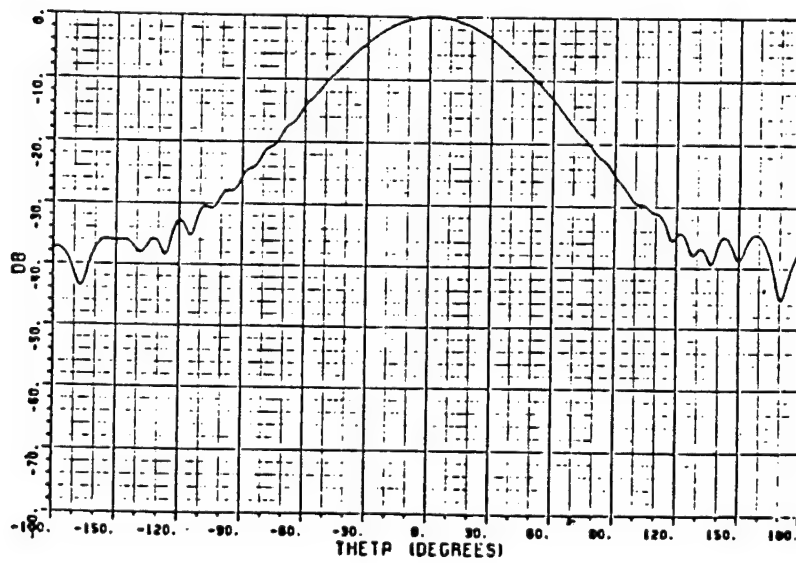


(b) E-plane

Figure 3. Calculated patterns of the dual mode horn.



(a) H-plane



(b) E-plane

Figure 4. Measured patterns of the dual mode horn.

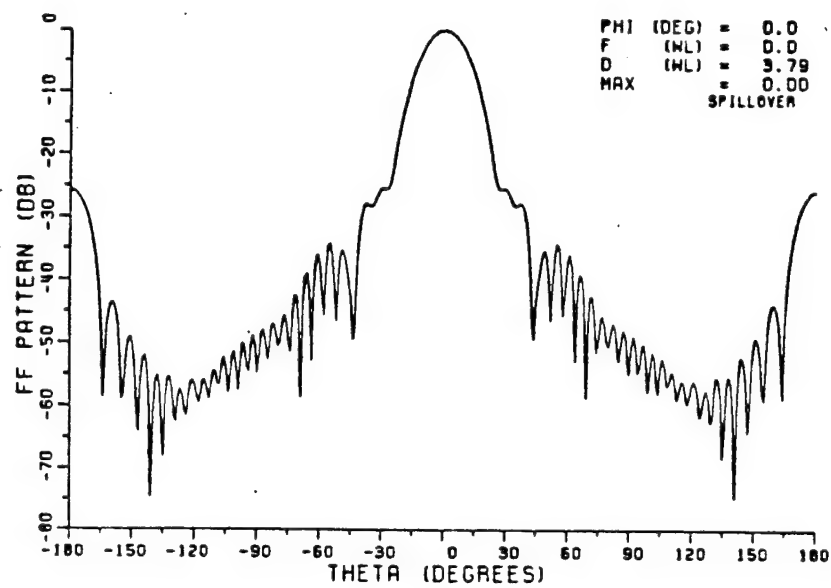
TABLE 1

INPUT DATA FOR PATTERN CALCULATION OF A DUAL MODE HORN

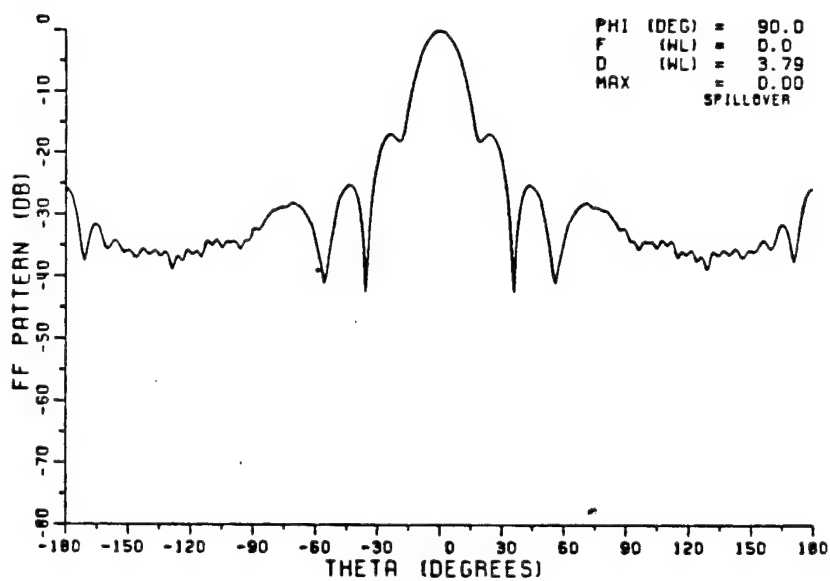
```
CM:          ***** BR5.DAT *****
CE: MOMENT METHOD FOR DUAL MODE HORN
FQ:
1 11.
BR:  NBR = 5 : DUAL MODE HORN
5
60. 1.384 1.447 0.75 1. 90.
PZ:  LFDOUT = F
3
0. 45. 90.
-180. 180. 1.
F
PP:
1
1 1
1 2
XQ:
```

Example 2:

In this example, the radiation patterns of a conical horn are calculated at 11.0 GHz. The calculated and measured patterns are given in Figures 5 and 6, respectively. The input data are given in Table 2.

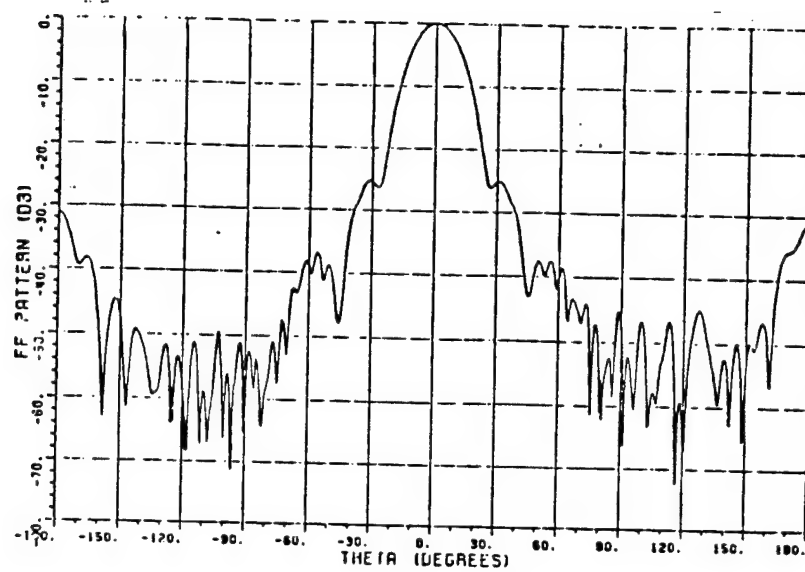


(a) H-plane

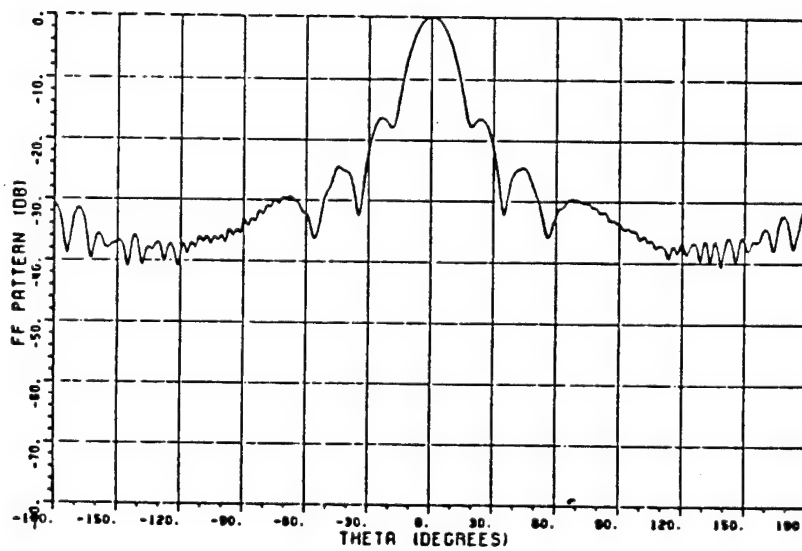


(b) E-plane

Figure 5. Calculated patterns of a conical horn.



(a) H-plane



(b) E-plane

Figure 6. Measured patterns of the conical horn.

TABLE 2

INPUT DATA FOR PATTERN CALCULATION FOR A CONICAL HORN

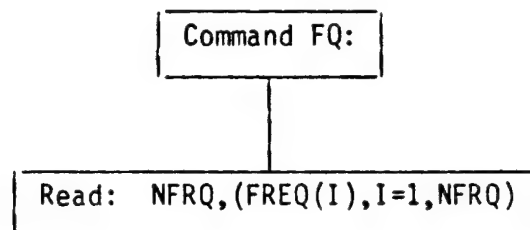
```

CM: ***** BR3 CASS.DAT *****
CE: MOMENT METHOD FOR CONICAL HORN
FQ:
1 11.
BR: NBR = 3 : CONICAL HORN
3
15. 4.072 0. 0.75 1. 90.
PZ: LFDOUT = F
3
0. 45. 90.
-180. 180. 1.
F
PP:
1
1 1
1 2
XQ:

```

Command FQ: FREQUENCY

This command enables the user to specify the frequencies for which patterns are to be computed.



1. READ: NFRQ, (FREQ(I), I=1, NFRQ)

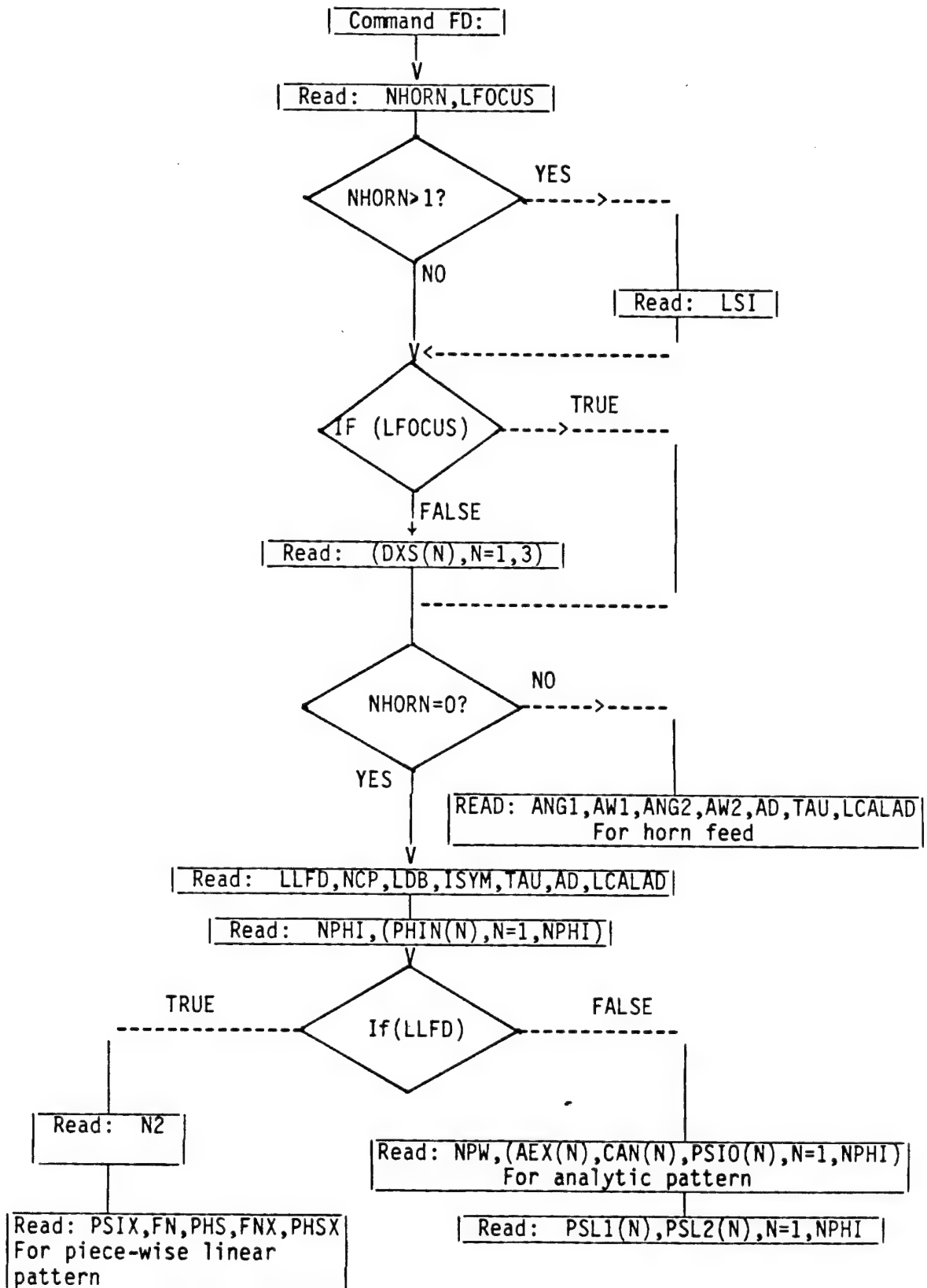
- a) NFRQ: This integer variable is used to define the number of frequency inputs. If the feed is frequency dependent, use only one input frequency FREQ(1) (NFRQ=1) in conjunction with a new input feed pattern for each frequency. Thus a new FD: Command must be used for each frequency with a frequency-dependent feed. Presently $1 < \text{NFRQ} < 10$.
- b) FREQ(I): This is a dimensioned real variable which defines the Ith frequency (in GHz) for which a given antenna design with a frequency independent feed pattern is to be run.

Command FD: FEED PATTERN

This command enables the user to specify the feed pattern. Feed patterns can be specified by piecewise linear feed data, analytic functions, or by feed horn dimensions.

NOTE: For offset reflectors, the TL: Command must also be used to tilt the feed axis.

BLOCK DIAGRAM FOR FEED PATTERN



1. READ: NHORN,LFOCUS

- a) NHORN: This integer variable specifies whether a horn feed is to be used or not. If a horn feed is to be used it specifies whether it is a regular horn or a corrugated horn as follows:

NHORN =0	SAMPLED OR ANALYTICAL FEED INPUT
NHORN =1	REGULAR HORN FEED
NHORN =2	CORRUGATED HORN FEED

- b) LFOCUS: This logical variable is used to tell the code whether the feed is located at the focus or not.

LFOCUS =TRUE	FEED IS FOCUSED
LFOCUS =FALSE	FEED IS DEFOCUSED

2. READ: LSI

This statement is executed for NHORN>1 only.

- a) LSI: This logical variable gives the option to use a line source integration (AI) in the forward half of the H-plane pattern for ordinary horn feeds in the FD: Command (NHORN>1). If LSI is false, as in the default data, GTD is used for all angles in the H-plane pattern (normally set false).

3. READ: (DXS(N),N=1,3)

This statement is skipped if LFOCUS=true.

- a) DXS(N): This dimensioned real variable is used to specify the displacement of the feed from the focus.

4. READ: LLFD,NCP,LDB,ISYM,TAU,AD,LCALAD

This statement is skipped if NHORN is not 0.

- a) LLFD: This logical variable is used to tell the code whether or not a piecewise linear feed pattern is to be used. If set false an analytic function is used.

LLFD=TRUE	INPUT FEED PATTERN IN TERMS OF LINEAR DATA POINTS
LLFD=FALSE	ANALYTIC FUNCTION

- b) NCP: This integer variable is used to tell the code whether or not the feed is circularly polarized.

NCP=0	FEED IS LINEARLY POLARIZED
NCP=-1	FEED IS LEFT CIRCULARLY POLARIZED
NCP=+1	FEED IS RIGHT CIRCULARLY POLARIZED

- c) LDB: This logical variable is used to tell the code whether or not the feed pattern input and output data are specified in dB or not. If LDB is false, feed pattern input and output are linear field values.

LDB=TRUE	FEED DATA INPUT IN DB
LDB=FALSE	LINEAR FEED DATA INPUT

- d) ISYM: This integer variable defines the type of symmetry for the feed pattern. Positive values are used for even symmetry (sum patterns) and negative values are used for odd symmetry (difference patterns). The absolute value ($IB = |ISYM|$) defines the regions of symmetry with respect to the feed coordinate system (x,y,z) shown in Figure 1.

ISYM =IB=0:	No symmetry
ISYM =IB=1:	Symmetry with respect to x and y axes
ISYM =IB=2:	Symmetry with respect to x axis
ISYM =IB=3:	Symmetry with respect to y axis

- e) TAU: This real variable is input in degrees and defines the linear polarization angle relative to the x-axis of the feed as shown in Figure 1.

TAU=0	FOR HORIZONTAL POLARIZATION
TAU=90	FOR VERTICAL POLARIZATION.

- f) AD: This variable defines the distance of the horn aperture from the feed reference point XS (see statement 9).
- g) LCALAD: This logical variable specifies that whether the phase center of the feed is to be calculated by the code or not. If $AD \neq 0$, this variable is ignored in the code (but still has to be input). In the Cassegrain reflector pattern calculation, LCALAD should be false when the subreflector patterns are used as feed patterns to calculate the main reflector patterns.

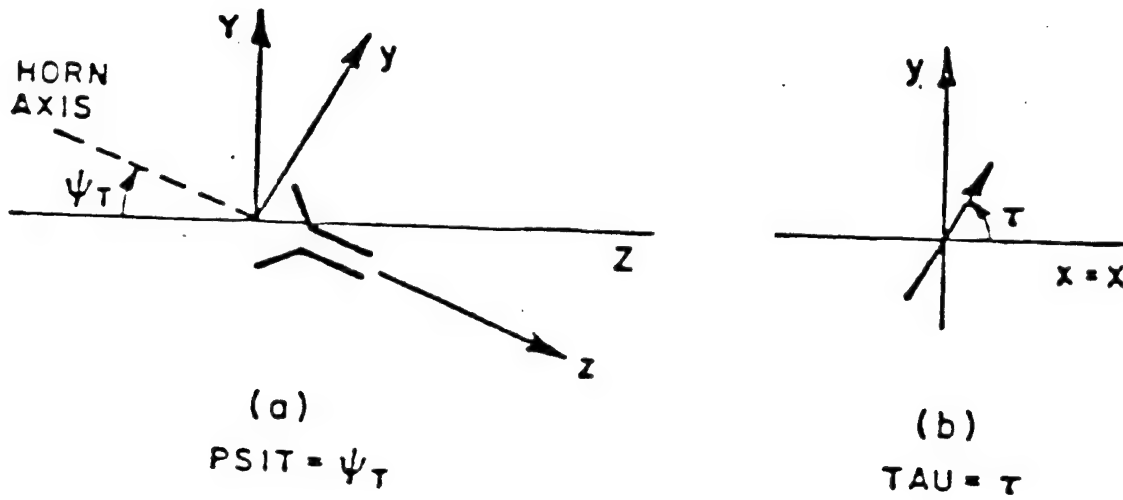


Figure 1. Coordinate system of feed horn and polarization angle tau when linearly polarized.

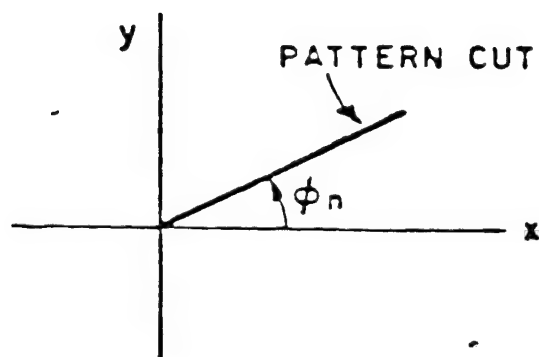


Figure 2. N-th input feed pattern cut, $\text{PHIN}(N) = \phi_n$.

4. READ: NPHI, (PHIN(N),N=1,NPHI)

This statement is skipped if NHORN is not 0.

- a) NPHI: This integer variable defines the number of input feed pattern cuts. Each input pattern corresponds to a ϕ -plane cut with respect to the feed axis (same as reflector axes for PSIT=0.) A circularly symmetric feed pattern is obtained if NPHI=1 and ISYM=1. Presently, $1 \leq \text{NPHI} \leq 15$.
- b) PHIN(N): This dimensioned real variable is input in degrees and defines the ϕ n angle of the N-th pattern cut as shown in Figure 2. The values must be input in monotonic order, i.e., $\text{PHIN}(N+1) > \text{PHIN}(N)$. The first value N=1 and the last value N=NPHI must be consistent with the type of pattern symmetry as shown below:

IB= ISYM	Type of Symmetry	PHIN(1)	PHIN(NPHI)
0	None	-180°	<180°
1	x&y axes	0°	90°
2	x-axis	0°	180°
3	y-axis	- 90°	90°

If ISYM=-2 or -3, the first and last pattern cuts, i.e., PHIN(1) and PHIN(NPHI), should be null patterns. Consequently, at least 3 pattern cuts (NPHI>2) are needed for ISYM=-2 or -3. For a feed pattern with no ϕ -symmetry (ISYM=0) the -180 degree pattern cut is also automatically stored as the +180 degree pattern cut. Presently $1 \leq N \leq 15$.

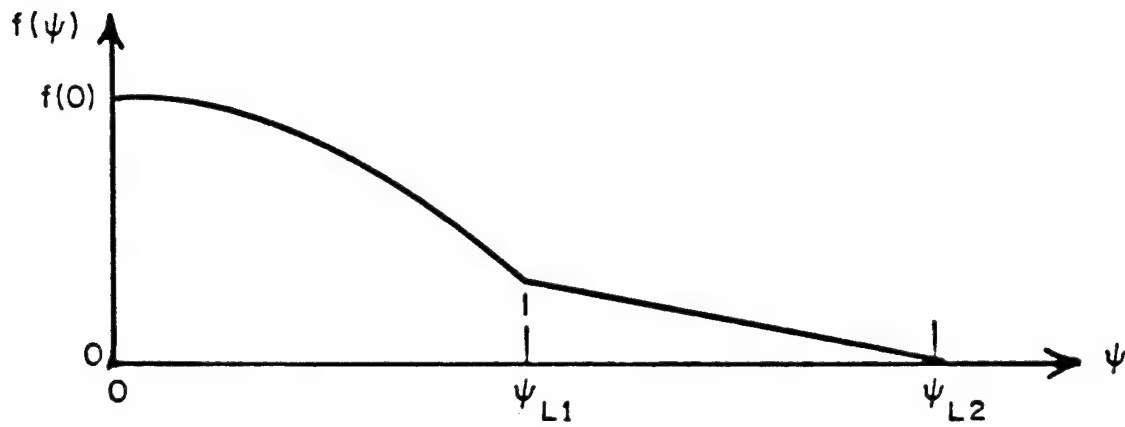


Figure 3. Analytic feed pattern with linear taper region.

*** ANALYTIC FEED PATTERN ***

5. READ: NPW,(AEX(N),CAN(N),PSIO(N),N=1,NPHI)

This statement is used to specify the analytic pattern (LLFD=false). The analytic functions are described in Appendix A. This read statement is skipped if LLFD=true, or if NHORN is not 0.

- a) NPW: This integer variable defines the power for the cosine or sine function.
- b) AEX(N),CAN(N),PSIO(N): These are dimensioned real variables which define the analytic pattern in the N-th ϕ -pattern cut. Presently $1 \leq N \leq 15$.

6. READ: LPSIL,(PSL1(N),PSL2(N),N=1,NPHI)

This statement is used to specify the region of linear tapering for analytic feed (LLFD=false). This statement is skipped if LLFD=true, or if NHORN is not 0.

- a) LPSIL: This logical variable specifies whether linear tapering is used or not. (The default of LPSIL is false.)
- b) PSL1(N): This dimensioned real variable specifies the starting angle of the linear taper in the Nth ϕ -pattern cut as shown in Figure 3.
- c) PSL2(N): This dimensioned real variable specifies the angle at which the linear taper ends in the Nth ϕ -pattern cut as shown in Figure 3. Past this angle, the field is zero.

*** LINEAR FEED INPUT PATTERN ***

7. READ: N2

This read statement is skipped if LLFD=false, or if NHORN is not 0.

- a) N2: This integer variable defines the number of feed pattern points to be read for all input ϕ -plane pattern cuts. It is used only for piecewise linear feed pattern input (LLFD=true). Presently $N2 \leq 377$.

8. READ: PSIX, FN, PHS, FNX, PHSX

This read statement is skipped if LLFD=false, or if NHORN is not 0. This read statement is executed N2 times for each value of PHIN(N), i.e., each PHI-cut.

- a) PSIX: This real variable defines the K-th angle (in degrees) for the piecewise linear feed input pattern as shown in Figure 4. Presently up to 377 points can be specified for each PHIN-cut.

NOTE: PSIX VALUES SHOULD BE IN MONOTONIC ORDER AND THE INITIAL PSIX VALUE FOR EACH PHIN-CUT SHOULD BE PSIX=0. $0 \leq \text{PSIX} < 180$.

- b) FN: This real variable defines the feed pattern value (in dB for LDB=true, or linear field value for LDB=false). Negative values may be used.
- c) PHS: This real variable is the phase of the feed input pattern in degrees.
- d) FNX: This real variable defines the cross-polarization feed pattern value (in dB for LDB=true, or linear field for LDB=false). Negative values may be used. If the cross-polarization field is not available, FNX=a large negative number (e.g., -300 dB) if LDB=true or FNX=0 if LDB=false.
- e) PHSX: This real variable is the phase in degrees of the cross-polarization field of feed.

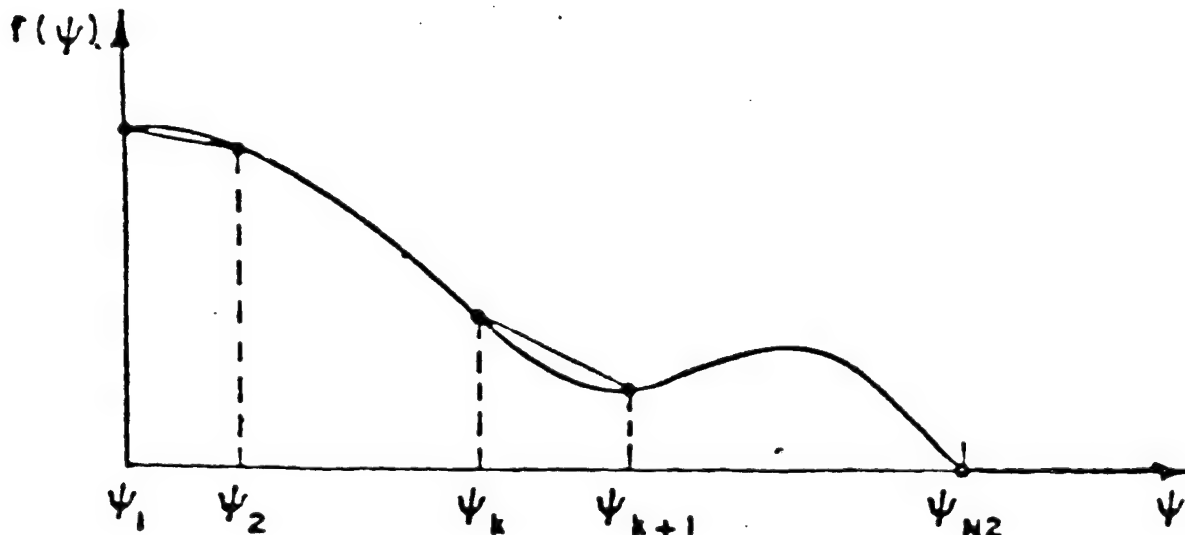


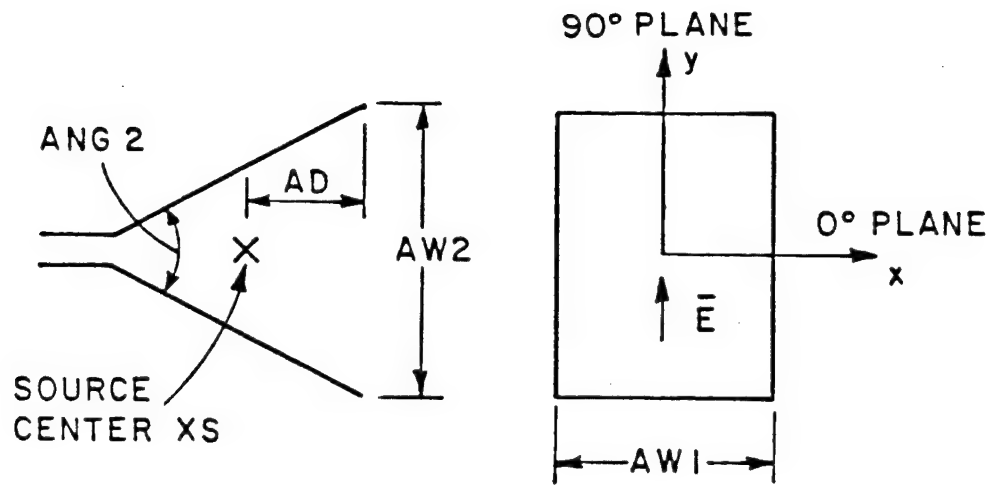
Figure 4. Piecewise linear approximation for feed patterns.

*** HORN FEED GEOMETRY INPUT ***

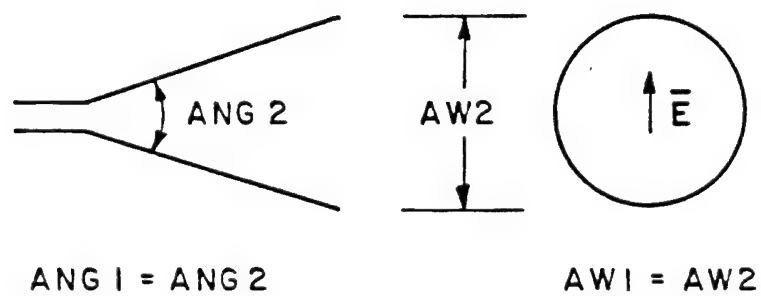
9. READ: ANG1,AW1,ANG2,AW2,AD,TAU,LCALAD

This statement is skipped if NHORN=0

- a) ANG1,ANG2: These real variables are input in degrees and define the full horn flare angles in the $\text{PHI}=0,90$ planes, respectively, as shown in Figure 5a.
- b) AW1,AW2: These real variables are input in the units specified by the variable IUNIT in the DG: Command. They define the horn aperture widths in the $\text{PHI}=0,90$ planes, respectively, as shown in Figure 5a.
- c) AD: This real variable is input in the units specified by the variable IUNIT in the DG: Command. It defines the distance of the horn aperture from the feed reference point, XS, as measured along the horn axis. See Figure 5a.
- d) TAU: This real variable is input in degrees and defines the linear polarization angle relative to the x-axis of the feed as shown in Figure 1b. $\text{TAU}=0$ for horizontal polarization, and $\text{TAU}=90$ for vertical polarization.
NOTE: TAU MUST BE EITHER 0. OR 90. FOR HORN FEEDS
- e) LCALAD: See READ: Statement 4.



a) Rectangular horn (Regular or Corrugated)



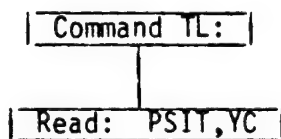
b) Conical horn (Corrugated only)

Figure 5. Horn feed geometries.

Command TL: OFFSET REFLECTOR GEOMETRY

This command enables the user to specify the tilt angle of the feed and the aperture center of the reflector on the Y-axis. This information is primarily useful for off-set reflectors.

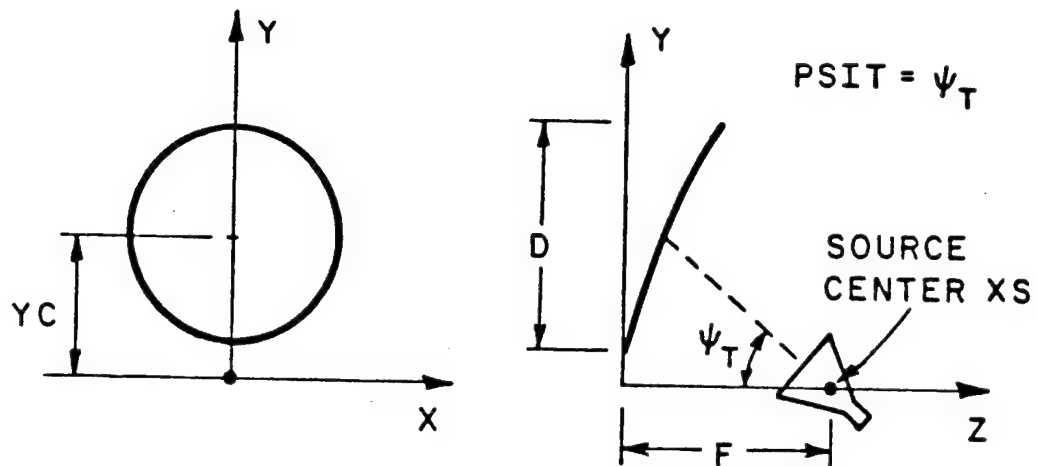
BLOCK DIAGRAM FOR FEED TILT



PSIT = Feed Axis Tilt
YC = OFFSET for Circular Reflectors

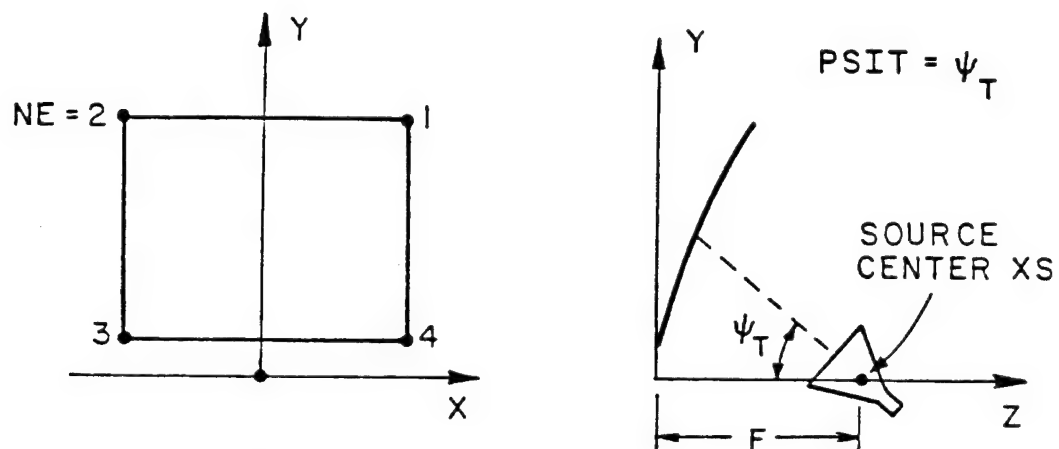
1. READ: PSIT,YC

- a) PSIT: This real variable is input in degrees and defines the angle by which the feed horn is tilted, in the y-z plane, from the negative z-axis, as shown in Figure 1.
- b) YC: This real variable is input in the units specified by the variable IUNIT and defines the aperture center of an offset reflector antenna. It is used only for circular rim shapes in which case the rim points are calculated from the reflector diameter D. Set YC=0 for non-circular rim shapes.



OFFSET REFLECTOR GEOMETRY (DG:,TL:)
(CIRCULAR : $D > 0$)

(a) Circular: $D > 0$



$RIM (NE, 1) = X_{NE}$

$RIM (NE, 2) = Y_{NE}$

OFFSET REFLECTOR GEOMETRY (DG:,TL:)
(NON-CIRCULAR : $D = 0$)

(b) Non-circular: $D = 0$

Figure 1. Offset reflector geometry (DG:,TL:)

COMMAND AF: ARRAY FEED

This command enables the user to input the information associated with the array feed.

1. Read: NFEED

- a) NFEED: This integer variable is used to define the number of elements for the array feed. Currently, $1 < \text{NFEED} < 101$.

2. Read: (XARO(N), N=1,3)

- b) XARO(N): This dimensional real variable is used to specify the origin of the feed coordinate system in the reflector coordinate system.

The following two read statements are executed NFEED times.

3. Read: (DXSAF(N,NF), N=1,3)

- a) DXSAF(N,NF): This dimensional real variable is used to specify the location of the array feed element in the feed coordinate system. In other words, it specifies the displacement from the origin XARO(N). An example of a 4-element array is shown in Figure 1.

4. Read: CRA(NF)

- a) CRA(NF): This dimensional complex variable is used to specify the complex weights of the array elements. Currently, all the array elements have the same pattern with different weights. The pattern is input in the FD: command and the weights are specified by this complex variable CRA(NF).

5. Read: PHRE, PSTL, PHFD

- a) PHRE: This real variable defines the phi plane in the reflector coordinate system in which the array feed is tilted.

- b) PSTL: This real variable is used to define the angle in degrees that the array feed is tilted.
- c) PHFD: This real variable defines the phi plane in the feed coordinate system in which the array feed is tilted.

Note that all the array elements have the same orientation defined by PHRE, PSTL, and PHFD, although it is not required to have all the elements on the same plane. Figure 2 shows the orientation of the array feed for a general case where PHRE, PSTL, and PHFD are arbitrarily specified. Figure 3 shows a common case where PHRE=90° and PHFD=90°.

There are two methods to get the reflector pattern if the array feed is used. The first method (method A) uses the AF: command to calculate the reflector pattern directly, and the second method (method B) uses the AF: command to calculate the far field pattern of the array feed as the first step of a two-step procedure.

Currently, method A is good only in the AI region, and it is more time-consuming because the ray tracing technique is applied to each element of the array feed to calculate the aperture field contribution.

Method B with the two-step procedure is recommended if the reflector is located in the far field region of the array feed. In the first run, the AF: command is used to specify the array and element locations and excitations. Also, the logical input LFDOUT is set true in the PZ: command so that the array feed pattern is stored during the first run. The PF: command for plotting feed patterns is borrowed to specify the number and angles of the phi-cut for the array feed pattern. After the first run, the array feed pattern is stored in the write unit #7, which should be edited to provide a suitable FD: command for the input data of the second run. In summary, the two-step procedure (when the reflector is in the far field of array feed) is given by:

1. The feed pattern of the array is calculated and stored by using LFDOUT=true.
2. The reflector pattern is calculated by using the array feed as a single composite feed.

If the aperture distribution of each array element is a known function, such as TE₁₁ circular mode, the AP: command can be used to generate the element pattern for the array feed. This can be done by setting LFDOUT to be true and using the AP: command to run the reflector code prior to either method A or method B.

NOTE: When LGTD = true or strut, plate and feed blockage are included in the calculation, method B must be used.

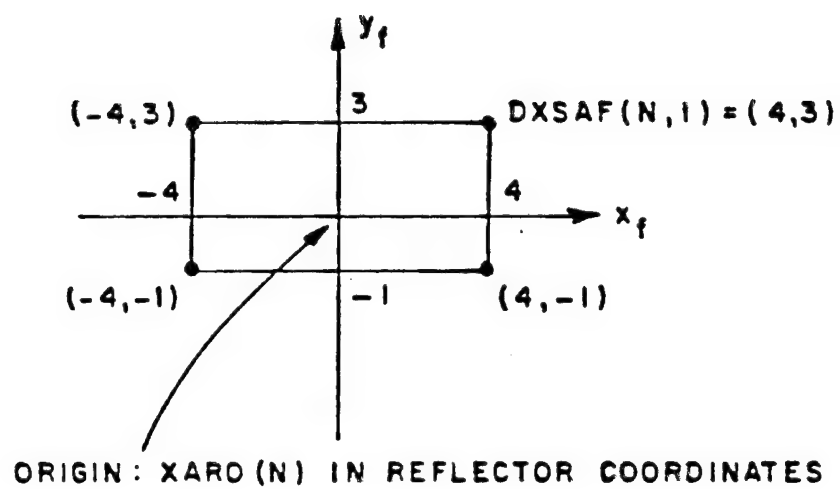
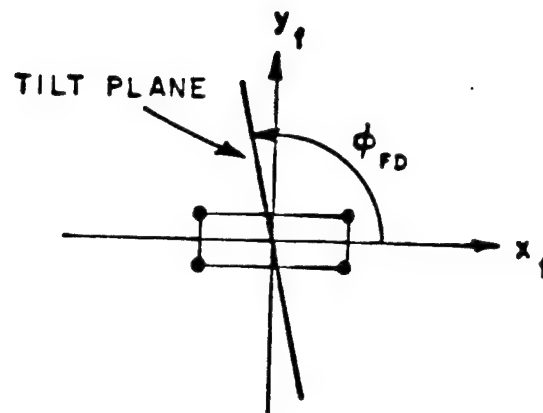
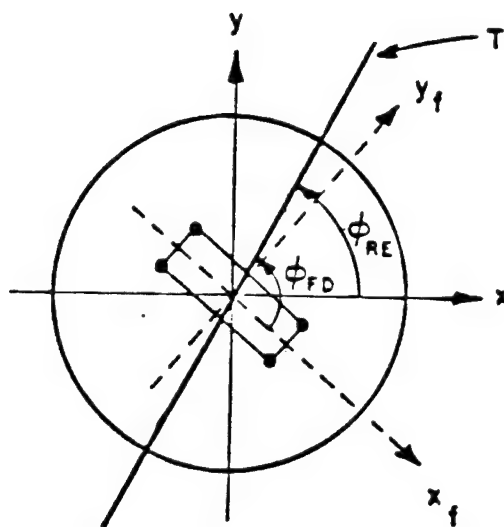


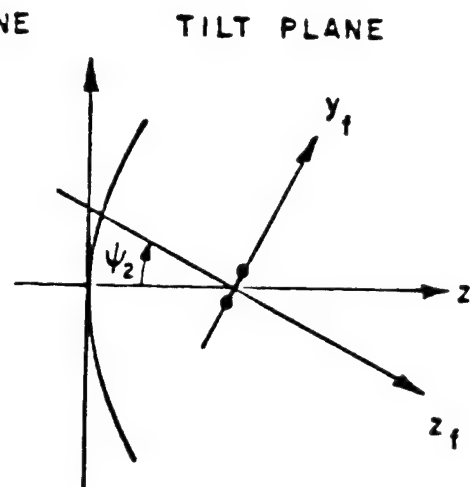
Figure 1. An example of 4-element array feed.



(a) ϕ_{FD} SPECIFIES THE TILT PLANE FOR THE ARRAY FEED.

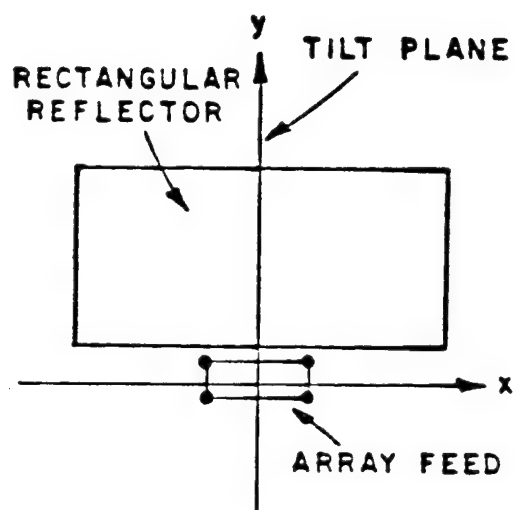


(b) FRONT VIEW.

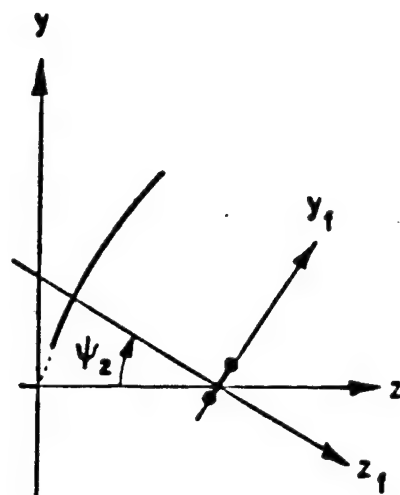


(c) SIDE VIEW FOR TILT PLANE ($\phi = \phi_{RE}$).

Figure 2. The orientation of the array feed for a general case. ($\psi_2 = \text{PSTL}$)



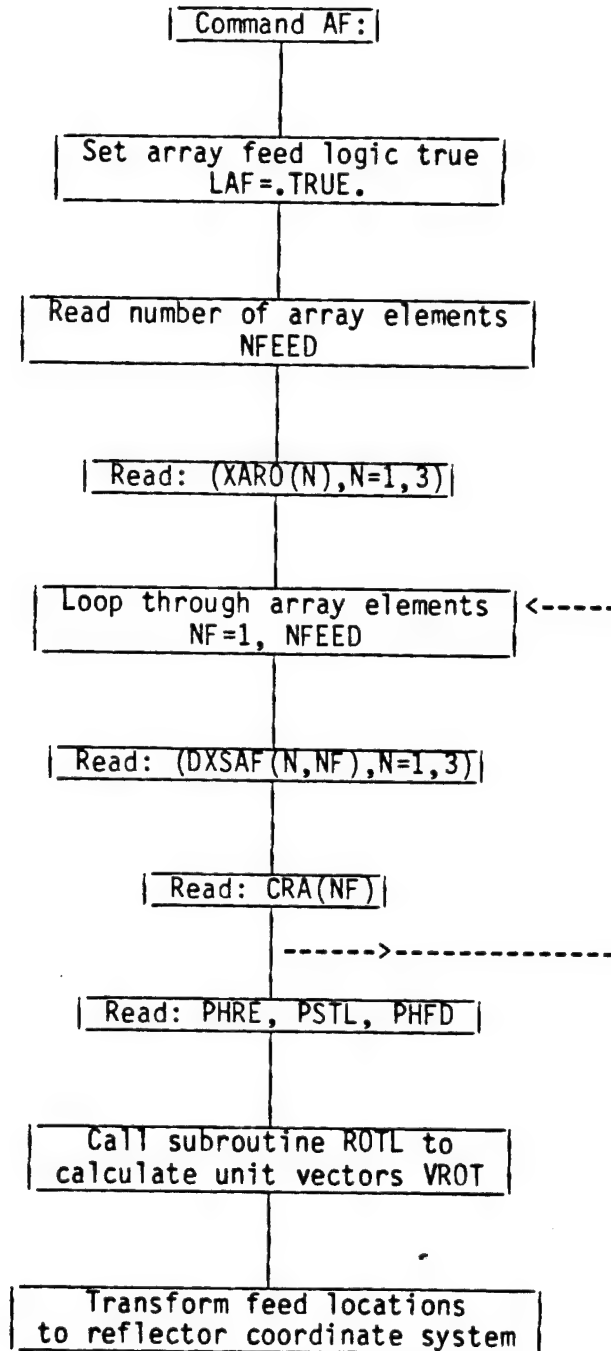
(a) FRONT VIEW



(b) SIDE VIEW

Figure 3. A common case where $\phi_{RE} = 90^\circ$ and $\phi_{FD} = 90^\circ$.

BLOCK DIAGRAM FOR ARRAY FEED



EXAMPLE:

This example demonstrates how the AF: command can be used for both method A and method B to calculate the reflector pattern with the array feed. A quadrant reflector as shown in Figure 4 with a 19-element array feed as shown in Figure 5 is used at the frequency of 15 GHz in this example. The elements for the array feed are TE₁₁ mode circular waveguides with diameter = 0.544λ ; and the pattern for a single element can be obtained by using the AP: command with inputs NMAG=11 and NPHA=1. The input data for this element pattern are given in Table 1.

In this example, the diameter of the array element is below the cutoff diameter for the TE₁₁ mode, thus CC(1)=1 so that the normalization constant for the TE₁₁ waveguide mode is ignored (see the AP: Command).

Table 1

INPUT DATA FOR CALCULATING ELEMENT PATTERN OF THE 19 ELEMENT ARRAY

```

CM:          ***** TE11AF.DAT *****
CM: CALCULATION OF CIRCULAR WAVEGUIDE TE11 MODE PATTERNS
CE:          D=0.544 WAVELENGTHS
DG:
1
3  0.18  0.005  0.005  0.544  0
TO:
F  30.  1.
F  0    0    0    0
F  F    F    F    0
T  T    F    0.8
T  F    F    F    F    0.  0.
F  F    0.  0.
AP:
11 1.  0.  0.  0.  0.  0.  ! CC(1) = 1, IGNORE NORMAL. CONSTANT
1  0.  0.  0.  0.  0.  0.
90.
FQ:
1  11.81102362
PZ: LFDOUT=T
3
0.  45.  90.
0.  90.  1.
T
XQ:

```

After this run, the element pattern data are stored in the write unit #7 as shown in Table 2. It then should be edited to provide the FD: command of the input data for the next run.

TABLE 2
OUTPUT DATA FROM UNIT #7 FOR THE ELEMENT PATTERN

0.000	-6.074	90.000	-87.617	-89.990
1.000	-6.075	90.000	-87.619	-89.990
2.000	-6.079	90.000	-87.627	-89.990
3.000	-6.085	90.000	-87.640	-89.990
4.000	-6.094	90.000	-87.657	-89.990
5.000	-6.106	90.000	-87.681	-89.990
6.000	-6.120	90.000	-87.709	-89.990
7.000	-6.137	90.000	-87.742	-89.990
8.000	-6.156	90.000	-87.780	-89.991
9.000	-6.177	90.000	-87.823	-89.990
10.000	-6.201	90.000	-87.871	-89.990
11.000	-6.228	90.000	-87.925	-89.990
12.000	-6.257	90.000	-87.983	-89.991
13.000	-6.289	90.000	-88.046	-89.991
14.000	-6.323	90.000	-88.115	-89.991
15.000	-6.359	90.000	-88.188	-89.991
16.000	-6.398	90.000	-88.266	-89.991
17.000	-6.440	90.000	-88.349	-89.991
18.000	-6.484	90.000	-88.437	-89.991
19.000	-6.530	90.000	-88.529	-89.991
20.000	-6.578	90.000	-88.627	-89.991
21.000	-6.629	90.000	-88.729	-89.991
22.000	-6.682	90.000	-88.836	-89.991
23.000	-6.737	90.000	-88.948	-89.992
24.000	-6.795	90.000	-89.064	-89.992
25.000	-6.855	90.000	-89.185	-89.992
26.000	-6.917	90.000	-89.310	-89.992
27.000	-6.981	90.000	-89.440	-89.992
28.000	-7.048	90.000	-89.574	-89.992
29.000	-7.117	90.000	-89.713	-89.992
30.000	-7.187	90.000	-89.856	-89.992
31.000	-7.260	90.000	-90.004	-89.992
32.000	-7.335	90.000	-90.155	-89.992
33.000	-7.412	90.000	-90.311	-89.992
34.000	-7.490	90.000	-90.471	-89.992
35.000	-7.571	90.000	-90.634	-89.992
36.000	-7.654	90.000	-90.802	-89.992
37.000	-7.738	90.000	-90.973	-89.993
38.000	-7.825	90.000	-91.149	-89.993
39.000	-7.913	90.000	-91.328	-89.993
40.000	-8.003	90.000	-91.510	-89.993
41.000	-8.095	90.000	-91.696	-89.993
42.000	-8.188	90.000	-91.885	-89.993
43.000	-8.283	90.000	-92.078	-89.993
44.000	-8.380	90.000	-92.274	-89.993
45.000	-8.479	90.000	-92.473	-89.993
46.000	-8.579	90.000	-92.674	-89.993
47.000	-8.680	90.000	-92.879	-89.993
48.000	-8.783	90.000	-93.086	-89.993
49.000	-8.888	90.000	-93.296	-89.994
50.000	-8.994	90.000	-93.508	-89.994
51.000	-9.102	90.000	-93.722	-89.994
52.000	-9.210	90.000	-93.939	-89.994
53.000	-9.321	90.000	-94.157	-89.994
54.000	-9.432	90.000	-94.377	-89.994
55.000	-9.545	90.000	-94.599	-89.994
56.000	-9.659	90.000	-94.822	-89.994
57.000	-9.775	90.000	-95.047	-89.994
58.000	-9.891	90.000	-95.272	-89.994

TABLE 2 - CONTINUED

59.000	-10.009	90.000	-95.499	-89.995
60.000	-10.128	90.000	-95.726	-89.995
61.000	-10.248	90.000	-95.953	-89.995
62.000	-10.370	90.000	-96.181	-89.995
63.000	-10.492	90.000	-96.409	-89.995
64.000	-10.615	90.000	-96.636	-89.995
65.000	-10.740	90.000	-96.864	-89.995
66.000	-10.865	90.000	-97.090	-89.995
67.000	-10.992	90.000	-97.316	-89.995
68.000	-11.120	90.000	-97.541	-89.996
69.000	-11.248	90.000	-97.764	-89.995
70.000	-11.378	90.000	-97.986	-89.996
71.000	-11.509	90.000	-98.207	-89.996
72.000	-11.640	90.000	-98.425	-89.996
73.000	-11.773	90.000	-98.641	-89.996
74.000	-11.906	90.000	-98.854	-89.996
75.000	-12.041	90.000	-99.066	-89.996
76.000	-12.176	90.000	-99.274	-89.996
77.000	-12.313	90.000	-99.479	-89.996
78.000	-12.450	90.000	-99.681	-89.996
79.000	-12.589	90.000	-99.880	-89.996
80.000	-12.729	90.000	-100.075	-89.996
81.000	-12.869	90.000	-100.266	-89.996
82.000	-13.011	90.000	-100.453	-89.997
83.000	-13.153	90.000	-100.637	-89.997
84.000	-13.297	90.000	-100.816	-89.997
85.000	-13.442	90.000	-100.991	-89.997
86.000	-13.588	90.000	-101.162	-89.997
87.000	-13.735	90.000	-101.329	-89.997
88.000	-13.884	90.000	-101.492	-89.997
89.000	-14.033	90.000	-101.650	-89.997
90.000	-300.000	0.000	-300.000	0.000
0.000	-6.075	90.000	-99.204	-87.982
1.000	-6.076	90.000	-119.555	-77.638
2.000	-6.080	90.000	-90.861	89.870
3.000	-6.088	90.000	-82.151	90.070
4.000	-6.098	90.000	-76.650	90.100
5.000	-6.111	90.000	-72.564	90.101
6.000	-6.127	90.000	-69.332	90.098
7.000	-6.146	90.000	-66.503	90.090
8.000	-6.167	90.000	-64.241	90.083
9.000	-6.192	90.000	-62.165	90.077
10.000	-6.219	90.000	-60.382	90.072
11.000	-6.250	90.000	-58.760	90.067
12.000	-6.283	90.000	-57.269	90.063
13.000	-6.319	90.000	-55.910	90.059
14.000	-6.357	90.000	-54.678	90.056
15.000	-6.398	90.000	-53.530	90.053
16.000	-6.443	90.000	-52.468	90.051
17.000	-6.489	90.000	-51.476	90.048
18.000	-6.539	90.000	-50.548	90.046
19.000	-6.591	90.000	-49.680	90.044
20.000	-6.646	90.000	-48.864	90.042
21.000	-6.704	90.000	-48.097	90.041
22.000	-6.764	90.000	-47.373	90.039
23.000	-6.826	90.000	-46.688	90.038
24.000	-6.891	90.000	-46.040	90.036
25.000	-6.959	90.000	-45.427	90.035
26.000	-7.029	90.000	-44.846	90.034
27.000	-7.102	90.000	-44.295	90.033
28.000	-7.177	90.000	-43.771	90.032
29.000	-7.254	90.000	-43.273	90.031
30.000	-7.333	90.000	-42.800	90.030
31.000	-7.415	90.000	-42.350	90.030
32.000	-7.499	90.000	-41.921	90.029
33.000	-7.586	90.000	-41.514	90.028

TABLE 2 - CONTINUED

34.000	-7.674	90.000	-41.126	90.028
35.000	-7.765	90.000	-40.757	90.027
36.000	-7.857	90.000	-40.406	90.026
37.000	-7.952	90.000	-40.073	90.026
38.000	-8.049	90.000	-39.755	90.025
39.000	-8.147	90.000	-39.454	90.025
40.000	-8.248	90.000	-39.167	90.024
41.000	-8.350	90.000	-38.895	90.024
42.000	-8.454	90.000	-38.637	90.024
43.000	-8.560	90.000	-38.392	90.023
44.000	-8.668	90.000	-38.161	90.023
45.000	-8.777	90.000	-37.941	90.022
46.000	-8.888	90.000	-37.735	90.022
47.000	-9.000	90.000	-37.539	90.022
48.000	-9.115	90.000	-37.356	90.021
49.000	-9.230	90.000	-37.183	90.021
50.000	-9.347	90.000	-37.021	90.021
51.000	-9.465	90.000	-36.870	90.021
52.000	-9.585	90.000	-36.729	90.020
53.000	-9.706	90.000	-36.598	90.020
54.000	-9.828	90.000	-36.477	90.020
55.000	-9.952	90.000	-36.365	90.020
56.000	-10.076	90.000	-36.262	90.020
57.000	-10.202	90.000	-36.168	90.019
58.000	-10.329	90.000	-36.083	90.019
59.000	-10.457	90.000	-36.007	90.019
60.000	-10.586	90.000	-35.940	90.019
61.000	-10.716	90.000	-35.881	90.019
62.000	-10.847	90.000	-35.830	90.018
63.000	-10.979	90.000	-35.787	90.018
64.000	-11.111	90.000	-35.752	90.018
65.000	-11.245	90.000	-35.724	90.018
66.000	-11.379	90.000	-35.705	90.018
67.000	-11.514	90.000	-35.693	90.018
68.000	-11.650	90.000	-35.688	90.018
69.000	-11.787	90.000	-35.691	90.018
70.000	-11.924	90.000	-35.701	90.018
71.000	-12.062	90.000	-35.719	90.017
72.000	-12.201	90.000	-35.743	90.017
73.000	-12.340	90.000	-35.775	90.017
74.000	-12.480	90.000	-35.814	90.017
75.000	-12.621	90.000	-35.859	90.017
76.000	-12.762	90.000	-35.912	90.017
77.000	-12.904	90.000	-35.971	90.017
78.000	-13.046	90.000	-36.038	90.017
79.000	-13.190	90.000	-36.111	90.017
80.000	-13.333	90.000	-36.191	90.017
81.000	-13.478	90.000	-36.278	90.017
82.000	-13.623	90.000	-36.371	90.017
83.000	-13.769	90.000	-36.472	90.017
84.000	-13.915	90.000	-36.579	90.017
85.000	-14.062	90.000	-36.693	90.017
86.000	-14.210	90.000	-36.813	90.017
87.000	-14.359	90.000	-36.941	90.017
88.000	-14.508	90.000	-37.075	90.017
89.000	-14.659	90.000	-37.216	90.017
90.000	-300.000	0.000	-300.000	0.000
0.000	-6.077	90.000	-90.435	-89.986
1.000	-6.078	90.000	-90.437	-90.408
2.000	-6.083	90.000	-90.444	-90.830
3.000	-6.091	90.000	-90.456	-91.253
4.000	-6.103	90.000	-90.472	-91.676
5.000	-6.117	90.000	-90.493	-92.099
6.000	-6.135	90.000	-90.519	-92.524
7.000	-6.156	90.000	-90.549	-92.949
8.000	-6.181	90.000	-90.584	-93.376

TABLE 2 - CONTINUED

9.000	-6.208	90.000	-90.624	-93.804
10.000	-6.239	90.000	-90.668	-94.234
11.000	-6.272	90.000	-90.717	-94.664
12.000	-6.309	90.000	-90.770	-95.098
13.000	-6.350	90.000	-90.828	-95.533
14.000	-6.393	90.000	-90.890	-95.970
15.000	-6.439	90.000	-90.957	-96.409
16.000	-6.488	90.000	-91.028	-96.851
17.000	-6.541	90.000	-91.104	-97.296
18.000	-6.596	90.000	-91.184	-97.744
19.000	-6.654	90.000	-91.268	-98.194
20.000	-6.716	90.000	-91.356	-98.647
21.000	-6.780	90.000	-91.449	-99.104
22.000	-6.847	90.000	-91.546	-99.564
23.000	-6.917	90.000	-91.646	-100.027
24.000	-6.990	90.000	-91.751	-100.494
25.000	-7.065	90.000	-91.860	-100.965
26.000	-7.144	90.000	-91.973	-101.439
27.000	-7.224	90.000	-92.089	-101.917
28.000	-7.308	90.000	-92.209	-102.400
29.000	-7.394	90.000	-92.333	-102.886
30.000	-7.483	90.000	-92.461	-103.377
31.000	-7.574	90.000	-92.592	-103.871
32.000	-7.668	90.000	-92.726	-104.370
33.000	-7.764	90.000	-92.864	-104.874
34.000	-7.863	90.000	-93.005	-105.382
35.000	-7.963	90.000	-93.149	-105.894
36.000	-8.066	90.000	-93.296	-106.410
37.000	-8.172	90.000	-93.446	-106.930
38.000	-8.279	90.000	-93.599	-107.455
39.000	-8.389	90.000	-93.755	-107.983
40.000	-8.500	90.000	-93.913	-108.516
41.000	-8.614	90.000	-94.074	-109.053
42.000	-8.729	90.000	-94.237	-109.594
43.000	-8.846	90.000	-94.403	-110.138
44.000	-8.966	90.000	-94.570	-110.685
45.000	-9.086	90.000	-94.740	-111.236
46.000	-9.209	90.000	-94.911	-111.790
47.000	-9.333	90.000	-95.085	-112.346
48.000	-9.459	90.000	-95.260	-112.904
49.000	-9.586	90.000	-95.436	-113.465
50.000	-9.715	90.000	-95.614	-114.027
51.000	-9.845	90.000	-95.793	-114.590
52.000	-9.977	90.000	-95.973	-115.153
53.000	-10.109	90.000	-96.154	-115.717
54.000	-10.243	90.000	-96.336	-116.280
55.000	-10.379	90.000	-96.519	-116.842
56.000	-10.515	90.000	-96.702	-117.402
57.000	-10.652	90.000	-96.885	-117.961
58.000	-10.790	90.000	-97.069	-118.515
59.000	-10.929	90.000	-97.253	-119.067
60.000	-11.069	90.000	-97.437	-119.613
61.000	-11.210	90.000	-97.621	-120.155
62.000	-11.352	90.000	-97.805	-120.690
63.000	-11.494	90.000	-97.989	-121.218
64.000	-11.637	90.000	-98.172	-121.738
65.000	-11.781	90.000	-98.354	-122.248
66.000	-11.925	90.000	-98.536	-122.750
67.000	-12.070	90.000	-98.717	-123.240
68.000	-12.215	90.000	-98.898	-123.719
69.000	-12.360	90.000	-99.077	-124.185
70.000	-12.506	90.000	-99.256	-124.638
71.000	-12.653	90.000	-99.433	-125.076
72.000	-12.800	90.000	-99.610	-125.498
73.000	-12.947	90.000	-99.785	-125.903
74.000	-13.094	90.000	-99.959	-126.292

TABLE 2 - CONTINUED

75.000	-13.242	90.000	-100.131	-126.662
76.000	-13.389	90.000	-100.303	-127.012
77.000	-13.538	90.000	-100.473	-127.343
78.000	-13.686	90.000	-100.641	-127.652
79.000	-13.834	90.000	-100.808	-127.940
80.000	-13.983	90.000	-100.974	-128.206
81.000	-14.132	90.000	-101.139	-128.448
82.000	-14.281	90.000	-101.302	-128.667
83.000	-14.430	90.000	-101.463	-128.861
84.000	-14.580	90.000	-101.623	-129.031
85.000	-14.730	90.000	-101.782	-129.175
86.000	-14.880	90.000	-101.939	-129.293
87.000	-15.030	90.000	-102.095	-129.386
88.000	-15.181	90.000	-102.250	-129.452
89.000	-15.332	90.000	-102.404	-129.492
90.000	-300.000	0.000	-300.000	0.000

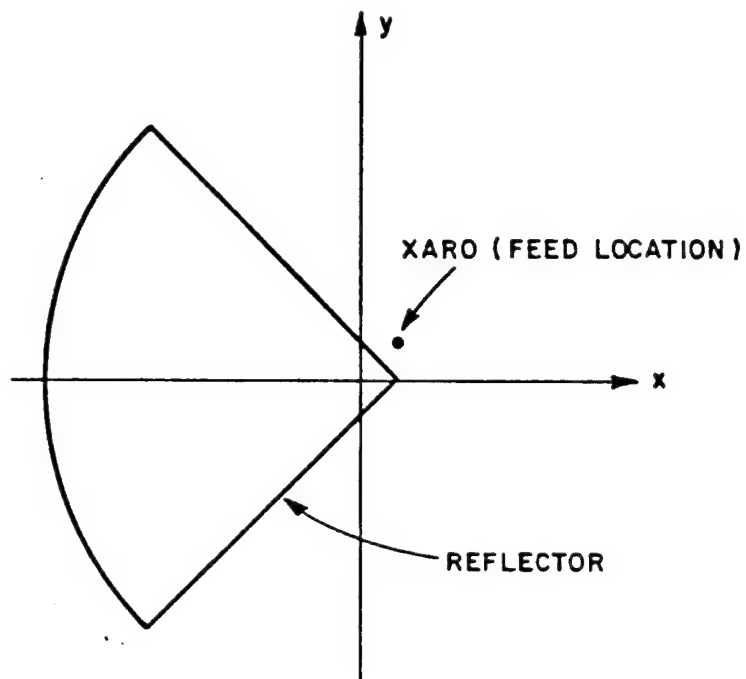


Figure 4. Front view of the quadrant reflector antenna.

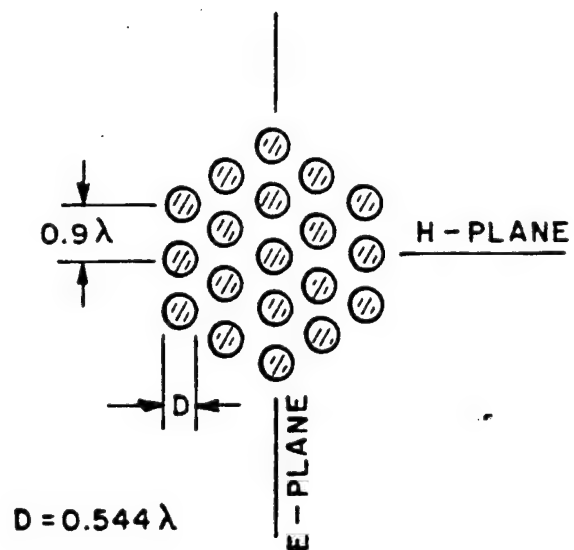


Figure 5. 19-element array feed.

1. Method A

The reflector pattern is calculated directly in this run. The input data are given in Table 3. Note that part of the FD: command is not listed since it comes from the data file FOR007.DAT as shown in Table 2.

INPUT DATA FOR CALCULATING THE QUADRANT REFLECTOR PATTERN (METHOD A)

```

CM: ***** RF19X.DAT *****
CM: EXAMPLE OF ARRAY FEED
CM: --- TILT= 21.6 DEG. ---
CM: --- AIC ONLY ---
CM: ARRAY FEED, NFEED=19
CE: CALCULATE REFLECTOR PATTERN DIRECTLY
DG: EDGES ROTATED 90 DEGREES
1
3 137.7 3. 3. 0 22
-70.22 78.02
-74.58 74.58
-80.79 67.79
-86.39 60.49
-91.34 52.73
-95.58 44.57
-99.11 36.07
-101.87 27.30
-103.86 18.31
-105.06 9.19
-105.47 0.00
-105.06 -9.19
-103.86 -18.31
-101.87 -27.30
-99.11 -36.07
-95.58 -44.57
-91.34 -52.73
-86.39 -60.49
-80.79 -67.79
-74.58 -74.58
-70.22 -78.02
7.80 0.00
TO: LAIC = T ONLY
F 180. 5.
F 27 27 1 55
F F F F 0
T T F 0.8
T F F F F F 0. 0.
F F 0. 0.
FD: TELL CIRCULAR WAVEGUIDE FOR SINGLE ELEMENT
0 T
T 0 T 1 90. 0. F
3 0. 45. 90.
91
0.000 -6.074 90.000 -87.617 -89.990
1.000 -6.075 90.000 -87.619 -89.990
2.000 -6.079 90.000 -87.627 -89.990
3.000 -6.085 90.000 -87.640 -89.990
4.000 -6.094 90.000 -87.657 -89.990
. . . . .
. . . . .
. . . . .
( see Table 2. )
. . . . .
86.000 -14.880 90.000 -101.939 -129.293
87.000 -15.030 90.000 -102.095 -129.380

```

TABLE 3 - CONTINUED

88.000	-15.181	90.000	-102.250	-129.452
89.000	-15.332	90.000	-102.404	-129.492
90.000	-300.000	0.000	-300.000	0.000

AF: 19 ELEMENTS ARRAY FEED

19

7.8	7.8	137.7	
0.	0.	0.	0.
1.	0.		
0.	-0.7087	0.	
0.75	0.		
0.6138	-0.3543	0.	
0.75	0.		
0.6138	0.3543	0.	
0.75	0.		
0.	0.7087	0.	
0.75	0.		
-0.6138	0.3543	0.	
0.75	0.		
-0.6138	-0.3543	0.	
0.75	0.		
0.	-1.4173	0.	
0.25	0.		
0.6138	-1.0630	0.	
0.25	0.		
1.2275	-0.7087	0.	
0.25	0.		
1.2275	0.	0.	
0.25	0.		
1.2275	0.7087	0.	
0.25	0.		
0.6138	1.0630	0.	
0.25	0.		
0.	1.4173	0.	
0.25	0.		
-0.6138	1.0630	0.	
0.25	0.		
-1.2275	0.7087	0.	
0.25	0.		
-1.2275	0.	0.	
0.25	0.		
-1.2275	-0.7087	0.	
0.25	0.		
-0.6138	-1.0630	0.	
0.25	0.		
90.	21.6	90.	

FQ:

1 15.

PZ:

1

-135

-12. 12. 0.05

F

PP:

1

1 1

1 2

XQ:

The reflector pattern for the $\phi = -135^\circ$ cut is shown in Figure 6. Note that the gain level is incorrect because a single element is used for the reference gain. Also note that with this method the total aperture fields are calculated by superimposing the aperture field of each array element. This is not necessary for this case because the reflector is in the far field of the feed.

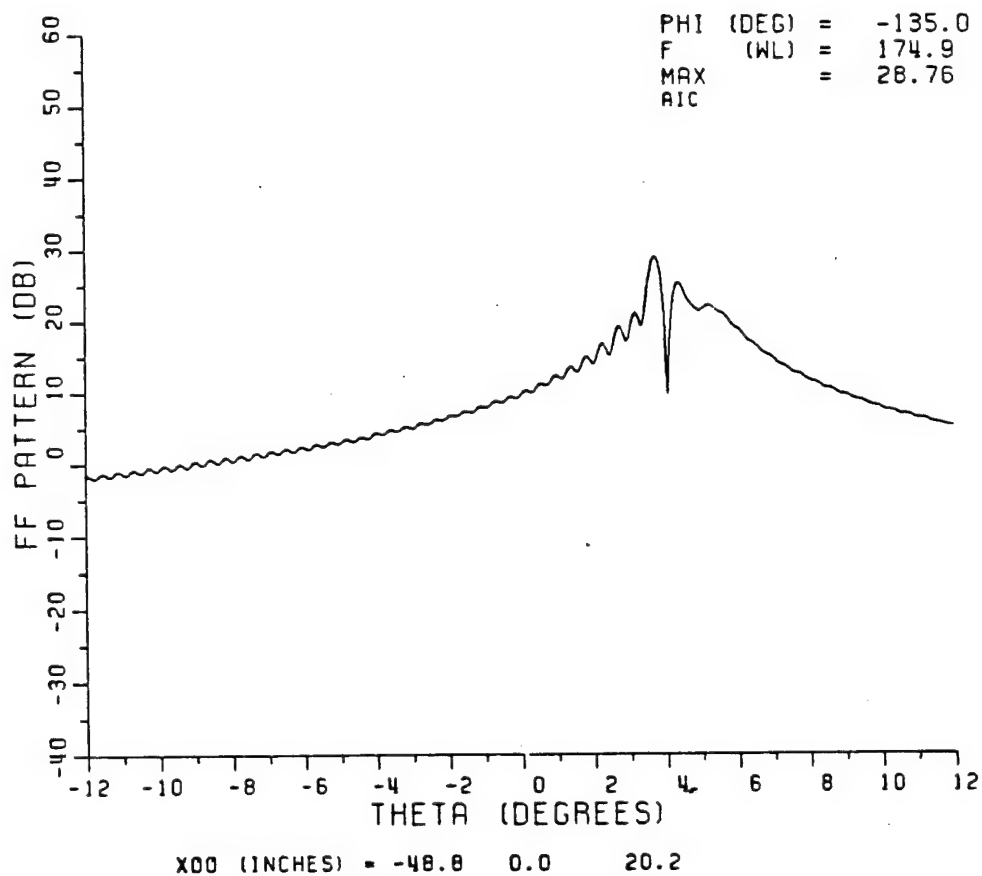


Figure 6. The reflector pattern for the $\phi = -135^\circ$ cut by using method A.

2. Method B

- 1) Step 1: The feed pattern of the array is calculated and stored in write unit #7 by using the input data given in Table 4.

INPUT DATA FOR CALCULATING ARRAY PATTERN (METHOD B)

```

CM: ***** RF19F2.DAT *****
CM:      EXAMPLE OF ARRAY FEED
CM:      CALCULATE THE ARRAY PATTERN
CE:      ARRAY FEED, NFEED=19
DG:      NOT AFFECTED IN THIS RUN
1
3      8.  12.  12.  24.  0
TO:
F      0.  0.
F      0  0  0  0
F      F  F  F  0
T      T  F  0.8
T      F  F  F  F  0.  0.
F      F  0.  0.
FD:  TE11 CIRCULAR WAVEGUIDE FOR SINGLE ELEMENT
0      T
T      0      T      1      90.  0.  F
3      0.  45.  90.
91
      0.000      -6.074      90.000      -87.617      -89.990
      1.000      -6.075      90.000      -87.619      -89.990
      2.000      -6.079      90.000      -87.627      -89.990
      3.000      -6.085      90.000      -87.640      -89.990
      4.000      -6.094      90.000      -87.657      -89.990
      .          .          .          .          .
      .          .          .          .          .
      .          .          .          .          .
      ( see Table 2. )
      .          .          .          .          .
      .          .          .          .          .
      86.000      -14.880      90.000      -101.939      -129.293
      87.000      -15.030      90.000      -102.095      -129.386
      88.000      -15.181      90.000      -102.250      -129.452
      89.000      -15.332      90.000      -102.404      -129.492
      90.000      -300.000      0.000      -300.000      0.000
AF:  19 ELEMENTS ARRAY FEED
19
0.  0.  137.7
0.  0.  0.
1.  0.  0.
0.  -0.7087  0.
0.75  0.
0.6138  -0.3543  0.
0.75  0.
0.6138  0.3543  0.
0.75  0.
0.  0.7087  0.
0.75  0.
-0.6138  0.3543  0.
0.75  0.
-0.6138  -0.3543  0.
0.75  0.
0.  -1.4173  0.
0.25  0.
0.6138  -1.0630  0.
0.25  0.
1.2275  -0.7087  0.
0.25  0.

```

TABLE 4 - CONTINUED

1.2275	0.	0.
0.25	0.	
1.2275	0.7087	0.
0.25	0.	
0.6138	1.0630	0.
0.25	0.	
0.	1.4173	0.
0.25	0.	
-0.6138	1.0630	0.
0.25	0.	
-1.2275	0.7087	0.
0.25	0.	
-1.2275	0.	0.
0.25	0.	
-1.2275	-0.7087	0.
0.25	0.	
-0.6138	-1.0630	0.
0.25	0.	
90.	21.6	90.
FQ:		
1	15.	
PF:		
10		
0.	10.	20.
0.	30.	40.
	50.	60.
	70.	80.
	90.	90.
1		
2		
PZ: LFDOUT=T		
1		
-135.		
12.	12.	0.05
T		
XQ:		

The output data in the unit #7 as shown in Table 5 are then edited for the input data for the FD: command in step 2.

TABLE 5

OUTPUT DATA FROM UNIT #7 FOR THE ARRAY PATTERN

0.000	12.514	90.000	-300.000	0.000
1.000	12.476	90.000	-300.000	0.000
2.000	12.360	90.000	-300.000	0.000
3.000	12.166	90.000	-300.000	0.000
4.000	11.894	90.000	-300.000	0.000
5.000	11.541	90.000	-300.000	0.000
6.000	11.107	90.000	-300.000	0.000
7.000	10.590	90.000	-300.000	0.000
8.000	9.988	90.000	-300.000	0.000
9.000	9.299	90.000	-300.000	0.000
10.000	8.517	90.000	-300.000	0.000
11.000	7.640	90.000	-300.000	0.000
12.000	6.662	90.000	-300.000	0.000
13.000	5.579	90.000	-300.000	0.000
14.000	4.385	90.000	-300.000	0.000
15.000	3.071	90.000	-300.000	0.000
16.000	1.629	90.000	-300.000	0.000
17.000	0.049	90.000	-300.000	0.000
18.000	-1.679	90.000	-300.000	0.000
19.000	-3.567	90.000	-300.000	0.000
20.000	-5.627	90.000	-300.000	0.000
21.000	-7.867	90.000	-300.000	0.000
22.000	-10.287	90.000	-300.000	0.000
23.000	-12.865	90.000	-300.000	0.000
24.000	-15.538	90.000	-300.000	0.000
25.000	-18.155	90.000	-300.000	0.000
26.000	-20.446	90.000	-300.000	0.000
27.000	-22.038	90.000	-300.000	0.000
28.000	-22.640	90.000	-300.000	0.000
29.000	-22.276	90.000	-300.000	0.000
30.000	-21.261	90.000	-300.000	0.000
31.000	-19.964	90.000	-300.000	0.000
32.000	-18.643	90.000	-300.000	0.000
33.000	-17.434	90.000	-300.000	0.000
34.000	-16.395	90.000	-300.000	0.000
35.000	-15.548	90.000	-300.000	0.000
36.000	-14.893	90.000	-300.000	0.000
37.000	-14.421	90.000	-300.000	0.000
38.000	-14.126	90.000	-300.000	0.000
39.000	-13.996	90.000	-300.000	0.000
40.000	-14.024	90.000	-300.000	0.000
41.000	-14.203	90.000	-300.000	0.000
42.000	-14.526	90.000	-300.000	0.000
43.000	-14.988	90.000	-300.000	0.000
44.000	-15.586	90.000	-300.000	0.000
45.000	-16.313	90.000	-300.000	0.000
46.000	-17.163	90.000	-300.000	0.000
47.000	-18.125	90.000	-300.000	0.000
48.000	-19.185	90.000	-300.000	0.000
49.000	-20.317	90.000	-300.000	0.000
50.000	-21.480	90.000	-300.000	0.000
51.000	-22.615	90.000	-300.000	0.000
52.000	-23.634	90.000	-300.000	0.000
53.000	-24.436	90.000	-300.000	0.000
54.000	-24.910	90.000	-300.000	0.000
55.000	-24.981	90.000	-300.000	0.000
56.000	-24.630	90.000	-300.000	0.000
57.000	-23.907	90.000	-300.000	0.000
58.000	-22.904	90.000	-300.000	0.000
59.000	-21.731	90.000	-300.000	0.000

TABLE 5 - CONTINUED

60.000	-20.475	90.000	-300.000	0.000
61.000	-19.205	90.000	-300.000	0.000
62.000	-17.964	90.000	-300.000	0.000
63.000	-16.779	90.000	-300.000	0.000
64.000	-15.664	90.000	-300.000	0.000
65.000	-14.626	90.000	-300.000	0.000
66.000	-13.666	90.000	-300.000	0.000
67.000	-12.783	90.000	-300.000	0.000
68.000	-11.976	90.000	-300.000	0.000
69.000	-11.238	90.000	-300.000	0.000
70.000	-10.568	90.000	-300.000	0.000
71.000	-9.961	90.000	-300.000	0.000
72.000	-9.413	90.000	-300.000	0.000
73.000	-8.922	90.000	-300.000	0.000
74.000	-8.482	90.000	-300.000	0.000
75.000	-8.093	90.000	-300.000	0.000
76.000	-7.749	90.000	-300.000	0.000
77.000	-7.450	90.000	-300.000	0.000
78.000	-7.192	90.000	-300.000	0.000
79.000	-6.975	90.000	-300.000	0.000
80.000	-6.795	90.000	-300.000	0.000
81.000	-6.651	90.000	-300.000	0.000
82.000	-6.542	90.000	-300.000	0.000
83.000	-6.466	90.000	-300.000	0.000
84.000	-6.422	90.000	-300.000	0.000
85.000	-6.411	90.000	-300.000	0.000
86.000	-6.429	90.000	-300.000	0.000
87.000	-6.478	90.000	-300.000	0.000
88.000	-6.557	90.000	-300.000	0.000
89.000	-6.665	90.000	-300.000	0.000
90.000	-292.618	0.000	-300.000	0.000
0.000	12.514	90.000	-71.604	-89.544
1.000	12.476	90.000	-76.165	-87.245
2.000	12.360	90.000	-69.907	-50.021
3.000	12.166	90.000	-68.169	-129.977
4.000	11.893	90.000	-67.223	-129.970
5.000	11.540	90.000	-66.675	-129.970
6.000	11.106	90.000	-66.398	-129.970
7.000	10.588	90.000	-66.295	-129.972
8.000	9.986	90.000	-66.405	-129.975
9.000	9.295	90.000	-66.646	-129.975
10.000	8.511	90.000	-67.046	-129.976
11.000	7.632	90.000	-67.579	-129.977
12.000	6.651	90.000	-68.244	-129.979
13.000	5.563	90.000	-69.046	-129.980
14.000	4.361	90.000	-69.993	-129.981
15.000	3.036	90.000	-71.082	-129.981
16.000	1.576	90.000	-72.327	-129.982
17.000	-0.032	90.000	-73.736	-129.982
18.000	-1.804	90.000	-75.325	-129.983
19.000	-3.762	90.000	-77.114	-129.983
20.000	-5.932	90.000	-79.130	-129.984
21.000	-8.352	90.000	-81.406	-129.984
22.000	-11.069	90.000	-83.991	-129.984
23.000	-14.147	90.000	-86.947	-129.985
24.000	-17.674	90.000	-90.361	-129.986
25.000	-21.768	90.000	-94.351	-129.986
26.000	-26.556	90.000	-99.043	-129.986
27.000	-32.040	90.000	-104.439	-129.987
28.000	-37.378	90.000	-109.697	-129.987
29.000	-39.553	90.000	-111.798	-129.987
30.000	-37.055	90.000	-109.235	-129.987
31.000	-33.082	90.000	-105.202	-129.987
32.000	-29.566	90.000	-101.630	-129.987
33.000	-26.798	90.000	-98.814	-129.988
34.000	-24.685	90.000	-96.659	-129.988

TABLE 5 - CONTINUED

35.000	-23.106	90.000	-95.042	-129.988
36.000	-21.964	90.000	-93.868	-129.988
37.000	-21.193	90.000	-93.069	-129.989
38.000	-20.747	90.000	-92.600	-129.989
39.000	-20.598	90.000	-92.434	-129.989
40.000	-20.735	90.000	-92.556	-129.989
41.000	-21.158	90.000	-92.969	-129.989
42.000	-21.885	90.000	-93.690	-129.989
43.000	-22.956	90.000	-94.759	-129.989
44.000	-24.447	90.000	-96.252	-129.989
45.000	-26.506	90.000	-98.316	-129.990
46.000	-29.448	90.000	-101.266	-129.990
47.000	-34.127	90.000	-105.958	-129.990
48.000	-44.964	90.000	-116.809	-129.990
49.000	-42.040	-90.000	-113.902	50.009
50.000	-33.721	-90.000	-105.604	50.009
51.000	-29.870	-90.000	-101.776	50.009
52.000	-27.513	-90.000	-99.445	50.009
53.000	-25.952	-90.000	-97.912	50.009
54.000	-24.912	-90.000	-96.903	50.009
55.000	-24.262	-90.000	-96.285	50.009
56.000	-23.932	-90.000	-95.989	50.009
57.000	-23.887	-90.000	-95.980	50.009
58.000	-24.116	-90.000	-96.246	50.009
59.000	-24.629	-90.000	-96.799	50.008
60.000	-25.461	-90.000	-97.671	50.008
61.000	-26.683	-90.000	-98.934	50.008
62.000	-28.435	-90.000	-100.729	50.008
63.000	-31.020	-90.000	-103.357	50.008
64.000	-35.244	-90.000	-107.625	50.008
65.000	-45.077	-90.000	-117.502	50.008
66.000	-43.314	90.000	-115.784	-129.992
67.000	-34.103	90.000	-106.617	-129.992
68.000	-29.655	90.000	-102.213	-129.993
69.000	-26.705	90.000	-99.307	-129.992
70.000	-24.514	90.000	-97.159	-129.993
71.000	-22.791	90.000	-95.480	-129.993
72.000	-21.388	90.000	-94.119	-129.993
73.000	-20.223	90.000	-92.995	-129.993
74.000	-19.242	90.000	-92.053	-129.993
75.000	-18.410	90.000	-91.260	-129.993
76.000	-17.700	90.000	-90.587	-129.993
77.000	-17.096	90.000	-90.018	-129.993
78.000	-16.582	90.000	-89.538	-129.993
79.000	-16.149	90.000	-89.136	-129.993
80.000	-15.787	90.000	-88.803	-129.993
81.000	-15.489	90.000	-88.531	-129.993
82.000	-15.251	90.000	-88.317	-129.994
83.000	-15.067	90.000	-88.155	-129.994
84.000	-14.934	90.000	-88.041	-129.994
85.000	-14.849	90.000	-87.972	-129.994
86.000	-14.810	90.000	-87.946	-129.994
87.000	-14.816	90.000	-87.962	-129.994
88.000	-14.864	90.000	-88.018	-129.994
89.000	-14.953	90.000	-88.112	-129.994
90.000	-300.000	0.000	-300.000	0.000
0.000	12.514	90.000	-74.179	-89.097
1.000	12.476	90.000	-83.262	-84.500
2.000	12.359	90.000	-70.625	-10.052
3.000	12.165	90.000	-66.949	-169.963
4.000	11.892	90.000	-64.777	-169.950
5.000	11.539	90.000	-63.315	-169.950
6.000	11.104	90.000	-62.314	-169.951
7.000	10.586	90.000	-61.576	-169.954
8.000	9.982	90.000	-61.175	-169.958
9.000	9.290	90.000	-60.946	-169.960

TABLE 5 - CONTINUED

10.000	8.504	90.000	-60.940	-169.962
11.000	7.621	90.000	-61.104	-169.965
12.000	6.635	90.000	-61.429	-169.967
13.000	5.538	90.000	-61.923	-169.969
14.000	4.322	90.000	-62.594	-169.970
15.000	2.974	90.000	-63.434	-169.971
16.000	1.479	90.000	-64.459	-169.972
17.000	-0.184	90.000	-65.684	-169.974
18.000	-2.046	90.000	-67.135	-169.975
19.000	-4.148	90.000	-68.854	-169.975
20.000	-6.558	90.000	-70.904	-169.976
21.000	-9.388	90.000	-73.396	-169.977
22.000	-12.849	90.000	-76.538	-169.978
23.000	-17.415	90.000	-80.805	-169.979
24.000	-24.635	90.000	-87.740	-169.980
25.000	-55.565	-90.000	-118.401	10.020
26.000	-26.388	-90.000	-88.969	10.020
27.000	-21.732	-90.000	-84.073	10.019
28.000	-19.538	-90.000	-81.650	10.019
29.000	-18.391	-90.000	-80.286	10.018
30.000	-17.831	-90.000	-79.521	10.018
31.000	-17.648	-90.000	-79.144	10.018
32.000	-17.719	-90.000	-79.029	10.017
33.000	-17.959	-90.000	-79.093	10.017
34.000	-18.302	-90.000	-79.270	10.017
35.000	-18.693	-90.000	-79.502	10.016
36.000	-19.079	-90.000	-79.738	10.016
37.000	-19.415	-90.000	-79.933	10.015
38.000	-19.665	-90.000	-80.048	10.015
39.000	-19.801	-90.000	-80.057	10.015
40.000	-19.811	-90.000	-79.946	10.015
41.000	-19.697	-90.000	-79.718	10.015
42.000	-19.475	-90.000	-79.388	10.015
43.000	-19.166	-90.000	-78.977	10.014
44.000	-18.798	-90.000	-78.514	10.014
45.000	-18.397	-90.000	-78.022	10.014
46.000	-17.987	-90.000	-77.527	10.014
47.000	-17.586	-90.000	-77.047	10.014
48.000	-17.212	-90.000	-76.599	10.013
49.000	-16.875	-90.000	-76.191	10.013
50.000	-16.582	-90.000	-75.834	10.013
51.000	-16.339	-90.000	-75.530	10.013
52.000	-16.149	-90.000	-75.285	10.012
53.000	-16.014	-90.000	-75.097	10.012
54.000	-15.933	-90.000	-74.969	10.012
55.000	-15.908	-90.000	-74.900	10.012
56.000	-15.936	-90.000	-74.887	10.012
57.000	-16.017	-90.000	-74.931	10.012
58.000	-16.148	-90.000	-75.028	10.012
59.000	-16.328	-90.000	-75.178	10.011
60.000	-16.555	-90.000	-75.378	10.011
61.000	-16.828	-90.000	-75.626	10.011
62.000	-17.144	-90.000	-75.920	10.011
63.000	-17.500	-90.000	-76.257	10.011
64.000	-17.895	-90.000	-76.636	10.011
65.000	-18.329	-90.000	-77.055	10.011
66.000	-18.796	-90.000	-77.510	10.011
67.000	-19.297	-90.000	-78.001	10.011
68.000	-19.829	-90.000	-78.524	10.010
69.000	-20.390	-90.000	-79.078	10.011
70.000	-20.977	-90.000	-79.660	10.010
71.000	-21.588	-90.000	-80.268	10.010
72.000	-22.221	-90.000	-80.898	10.010
73.000	-22.872	-90.000	-81.548	10.010
74.000	-23.539	-90.000	-82.214	10.010
75.000	-24.219	-90.000	-82.894	10.010

TABLE 5 - CONTINUED

76.000	-24.907	-90.000	-83.584	10.010
77.000	-25.601	-90.000	-84.278	10.010
78.000	-26.293	-90.000	-84.973	10.010
79.000	-26.982	-90.000	-85.664	10.010
80.000	-27.659	-90.000	-86.343	10.010
81.000	-28.319	-90.000	-87.006	10.010
82.000	-28.955	-90.000	-87.644	10.009
83.000	-29.559	-90.000	-88.251	10.009
84.000	-30.125	-90.000	-88.819	10.009
85.000	-30.643	-90.000	-89.340	10.009
86.000	-31.108	-90.000	-89.806	10.009
87.000	-31.511	-90.000	-90.211	10.009
88.000	-31.847	-90.000	-90.548	10.009
89.000	-32.112	-90.000	-90.813	10.009
90.000	-300.000	0.000	-300.000	0.000
0.000	12.514	90.000	-76.755	-88.651
1.000	12.475	90.000	-90.359	-81.755
2.000	12.359	90.000	-71.344	29.917
3.000	12.164	90.000	-65.729	150.050
4.000	11.891	90.000	-62.331	150.070
5.000	11.538	90.000	-59.956	150.071
6.000	11.103	90.000	-58.230	150.069
7.000	10.584	90.000	-56.856	150.063
8.000	9.980	90.000	-55.944	150.058
9.000	9.286	90.000	-55.245	150.055
10.000	8.499	90.000	-54.833	150.051
11.000	7.613	90.000	-54.626	150.048
12.000	6.624	90.000	-54.609	150.045
13.000	5.522	90.000	-54.791	150.042
14.000	4.298	90.000	-55.180	150.040
15.000	2.939	90.000	-55.758	150.038
16.000	1.425	90.000	-56.547	150.037
17.000	-0.267	90.000	-57.561	150.035
18.000	-2.175	90.000	-58.832	150.034
19.000	-4.353	90.000	-60.412	150.032
20.000	-6.894	90.000	-62.389	150.031
21.000	-9.961	90.000	-64.923	150.030
22.000	-13.899	90.000	-68.357	150.029
23.000	-19.662	90.000	-73.641	150.028
24.000	-32.829	90.000	-86.352	150.027
25.000	-27.346	-90.000	-80.435	-29.974
26.000	-20.458	-90.000	-73.134	-29.975
27.000	-17.416	-90.000	-69.697	-29.975
28.000	-15.703	-90.000	-67.607	-29.976
29.000	-14.675	-90.000	-66.219	-29.977
30.000	-14.062	-90.000	-65.263	-29.977
31.000	-13.726	-90.000	-64.597	-29.977
32.000	-13.578	-90.000	-64.133	-29.978
33.000	-13.560	-90.000	-63.812	-29.979
34.000	-13.628	-90.000	-63.590	-29.979
35.000	-13.750	-90.000	-63.432	-29.979
36.000	-13.899	-90.000	-63.315	-29.980
37.000	-14.057	-90.000	-63.216	-29.980
38.000	-14.207	-90.000	-63.119	-29.981
39.000	-14.341	-90.000	-63.017	-29.981
40.000	-14.454	-90.000	-62.902	-29.982
41.000	-14.545	-90.000	-62.775	-29.982
42.000	-14.616	-90.000	-62.637	-29.982
43.000	-14.673	-90.000	-62.493	-29.982
44.000	-14.724	-90.000	-62.351	-29.982
45.000	-14.775	-90.000	-62.216	-29.983
46.000	-14.836	-90.000	-62.099	-29.983
47.000	-14.914	-90.000	-62.006	-29.983
48.000	-15.017	-90.000	-61.945	-29.984
49.000	-15.150	-90.000	-61.922	-29.984
50.000	-15.322	-90.000	-61.942	-29.984

TABLE 5 - CONTINUED

51.000	-15.536	-90.000	-62.012	-29.984
52.000	-15.797	-90.000	-62.136	-29.985
53.000	-16.111	-90.000	-62.317	-29.985
54.000	-16.479	-90.000	-62.560	-29.985
55.000	-16.907	-90.000	-62.867	-29.985
56.000	-17.399	-90.000	-63.244	-29.985
57.000	-17.959	-90.000	-63.693	-29.985
58.000	-18.591	-90.000	-64.221	-29.985
59.000	-19.303	-90.000	-64.833	-29.986
60.000	-20.101	-90.000	-65.536	-29.986
61.000	-20.995	-90.000	-66.340	-29.986
62.000	-21.998	-90.000	-67.257	-29.986
63.000	-23.127	-90.000	-68.305	-29.986
64.000	-24.406	-90.000	-69.507	-29.986
65.000	-25.871	-90.000	-70.899	-29.986
66.000	-27.576	-90.000	-72.535	-29.986
67.000	-29.609	-90.000	-74.503	-29.986
68.000	-32.129	-90.000	-76.962	-29.987
69.000	-35.467	-90.000	-80.242	-29.986
70.000	-40.517	-90.000	-85.237	-29.987
71.000	-52.100	-90.000	-96.771	-29.988
72.000	-48.064	90.000	-92.687	150.012
73.000	-40.109	90.000	-84.688	150.013
74.000	-36.314	90.000	-80.853	150.013
75.000	-33.898	90.000	-78.399	150.013
76.000	-32.184	90.000	-76.650	150.013
77.000	-30.901	90.000	-75.334	150.013
78.000	-29.908	90.000	-74.313	150.013
79.000	-29.131	90.000	-73.508	150.013
80.000	-28.515	90.000	-72.869	150.013
81.000	-28.030	90.000	-72.363	150.013
82.000	-27.652	90.000	-71.965	150.012
83.000	-27.364	90.000	-71.661	150.012
84.000	-27.154	90.000	-71.436	150.012
85.000	-27.012	90.000	-71.282	150.012
86.000	-26.932	90.000	-71.192	150.012
87.000	-26.908	90.000	-71.160	150.012
88.000	-26.936	90.000	-71.184	150.012
89.000	-27.015	90.000	-71.259	150.012
90.000	-300.000	0.000	-300.000	0.000
0.000	12.513	90.000	-79.330	-88.204
1.000	12.475	90.000	-97.456	-79.010
2.000	12.359	90.000	-72.063	69.886
3.000	12.164	90.000	-64.510	110.063
4.000	11.890	90.000	-59.885	110.090
5.000	11.536	90.000	-56.597	110.091
6.000	11.101	90.000	-54.147	110.088
7.000	10.582	90.000	-52.136	110.081
8.000	9.978	90.000	-50.713	110.075
9.000	9.283	90.000	-49.542	110.070
10.000	8.497	90.000	-48.723	110.065
11.000	7.611	90.000	-48.142	110.061
12.000	6.624	90.000	-47.778	110.057
13.000	5.525	90.000	-47.640	110.053
14.000	4.307	90.000	-47.733	110.051
15.000	2.958	90.000	-48.029	110.048
16.000	1.460	90.000	-48.548	110.046
17.000	-0.205	90.000	-49.294	110.044
18.000	-2.069	90.000	-50.294	110.042
19.000	-4.173	90.000	-51.585	110.040
20.000	-6.585	90.000	-53.229	110.038
21.000	-9.418	90.000	-55.334	110.037
22.000	-12.880	90.000	-58.105	110.036
23.000	-17.447	90.000	-62.014	110.035
24.000	-24.660	90.000	-68.600	110.033
25.000	-56.231	-90.000	-99.573	-69.967

TABLE 5 - CONTINUED

26.000	-26.457	-90.000	-69.227	-69.969
27.000	-21.796	-90.000	-64.018	-69.970
28.000	-19.603	-90.000	-61.300	-69.971
29.000	-18.457	-90.000	-59.651	-69.972
30.000	-17.900	-90.000	-58.612	-69.972
31.000	-17.720	-90.000	-57.967	-69.972
32.000	-17.794	-90.000	-57.593	-69.973
33.000	-18.037	-90.000	-57.407	-69.974
34.000	-18.384	-90.000	-57.339	-69.974
35.000	-18.778	-90.000	-57.333	-69.975
36.000	-19.167	-90.000	-57.338	-69.976
37.000	-19.507	-90.000	-57.307	-69.976
38.000	-19.760	-90.000	-57.201	-69.977
39.000	-19.899	-90.000	-56.996	-69.977
40.000	-19.913	-90.000	-56.675	-69.978
41.000	-19.803	-90.000	-56.243	-69.978
42.000	-19.584	-90.000	-55.713	-69.978
43.000	-19.280	-90.000	-55.108	-69.979
44.000	-18.917	-90.000	-54.454	-69.979
45.000	-18.520	-90.000	-53.776	-69.980
46.000	-18.115	-90.000	-53.100	-69.980
47.000	-17.719	-90.000	-52.442	-69.980
48.000	-17.350	-90.000	-51.820	-69.981
49.000	-17.017	-90.000	-51.243	-69.981
50.000	-16.730	-90.000	-50.719	-69.981
51.000	-16.491	-90.000	-50.254	-69.981
52.000	-16.307	-90.000	-49.849	-69.982
53.000	-16.177	-90.000	-49.507	-69.982
54.000	-16.101	-90.000	-49.227	-69.982
55.000	-16.081	-90.000	-49.009	-69.982
56.000	-16.113	-90.000	-48.852	-69.982
57.000	-16.198	-90.000	-48.754	-69.982
58.000	-16.334	-90.000	-48.713	-69.982
59.000	-16.519	-90.000	-48.729	-69.983
60.000	-16.750	-90.000	-48.798	-69.983
61.000	-17.027	-90.000	-48.919	-69.983
62.000	-17.347	-90.000	-49.088	-69.983
63.000	-17.707	-90.000	-49.305	-69.983
64.000	-18.106	-90.000	-49.567	-69.983
65.000	-18.543	-90.000	-49.872	-69.983
66.000	-19.015	-90.000	-50.218	-69.983
67.000	-19.519	-90.000	-50.603	-69.983
68.000	-20.054	-90.000	-51.024	-69.984
69.000	-20.618	-90.000	-51.479	-69.983
70.000	-21.208	-90.000	-51.966	-69.984
71.000	-21.822	-90.000	-52.484	-69.984
72.000	-22.458	-90.000	-53.027	-69.984
73.000	-23.111	-90.000	-53.594	-69.984
74.000	-23.780	-90.000	-54.183	-69.984
75.000	-24.462	-90.000	-54.788	-69.984
76.000	-25.152	-90.000	-55.408	-69.984
77.000	-25.847	-90.000	-56.036	-69.984
78.000	-26.541	-90.000	-56.671	-69.984
79.000	-27.231	-90.000	-57.304	-69.984
80.000	-27.908	-90.000	-57.932	-69.984
81.000	-28.569	-90.000	-58.547	-69.984
82.000	-29.206	-90.000	-59.142	-69.985
83.000	-29.811	-90.000	-59.712	-69.985
84.000	-30.376	-90.000	-60.246	-69.985
85.000	-30.895	-90.000	-60.739	-69.985
86.000	-31.359	-90.000	-61.181	-69.985
87.000	-31.763	-90.000	-61.568	-69.985
88.000	-32.099	-90.000	-61.892	-69.985
89.000	-32.363	-90.000	-62.149	-69.985
90.000	-300.000	0.000	-300.000	0.000
0.000	12.513	90.000	-79.643	-88.204

TABLE 5 - CONTINUED

1.000	12.475	90.000	-97.769	-79.057
2.000	12.359	90.000	-72.376	109.792
3.000	12.163	90.000	-64.822	109.923
4.000	11.889	90.000	-60.198	109.903
5.000	11.535	90.000	-56.909	109.857
6.000	11.100	90.000	-54.459	109.807
7.000	10.580	90.000	-52.447	109.752
8.000	9.976	90.000	-51.024	109.699
9.000	9.281	90.000	-49.852	109.646
10.000	8.496	90.000	-49.030	109.594
11.000	7.613	90.000	-48.446	109.541
12.000	6.629	90.000	-48.077	109.490
13.000	5.537	90.000	-47.930	109.438
14.000	4.332	90.000	-48.009	109.386
15.000	3.003	90.000	-48.283	109.335
16.000	1.538	90.000	-48.767	109.284
17.000	-0.074	90.000	-49.458	109.232
18.000	-1.851	90.000	-50.368	109.180
19.000	-3.813	90.000	-51.516	109.129
20.000	-5.989	90.000	-52.920	109.077
21.000	-8.414	90.000	-54.615	109.025
22.000	-11.135	90.000	-56.643	108.972
23.000	-14.216	90.000	-59.063	108.920
24.000	-17.745	90.000	-61.962	108.866
25.000	-21.838	90.000	-65.453	108.813
26.000	-26.619	90.000	-69.659	108.759
27.000	-32.083	90.000	-74.573	108.705
28.000	-37.386	90.000	-79.347	108.651
29.000	-39.553	90.000	-81.007	108.596
30.000	-37.106	90.000	-78.074	108.540
31.000	-33.178	90.000	-73.678	108.485
32.000	-29.690	90.000	-69.738	108.429
33.000	-26.941	90.000	-66.555	108.372
34.000	-24.843	90.000	-64.038	108.316
35.000	-23.276	90.000	-62.068	108.258
36.000	-22.146	90.000	-60.548	108.200
37.000	-21.386	90.000	-59.413	108.142
38.000	-20.952	90.000	-58.615	108.083
39.000	-20.814	90.000	-58.128	108.024
40.000	-20.963	90.000	-57.937	107.964
41.000	-21.397	90.000	-58.044	107.904
42.000	-22.137	90.000	-58.467	107.844
43.000	-23.221	90.000	-59.245	107.783
44.000	-24.729	90.000	-60.456	107.722
45.000	-26.807	90.000	-62.247	107.660
46.000	-29.777	90.000	-64.941	107.598
47.000	-34.511	90.000	-69.407	107.537
48.000	-45.627	90.000	-80.264	107.474
49.000	-42.077	-90.000	-76.463	-72.589
50.000	-33.927	-90.000	-68.070	-72.651
51.000	-30.121	-90.000	-64.031	-72.714
52.000	-27.789	-90.000	-61.472	-72.777
53.000	-26.246	-90.000	-59.710	-72.840
54.000	-25.220	-90.000	-58.474	-72.902
55.000	-24.582	-90.000	-57.631	-72.965
56.000	-24.261	-90.000	-57.113	-73.027
57.000	-24.224	-90.000	-56.886	-73.090
58.000	-24.460	-90.000	-56.939	-73.151
59.000	-24.979	-90.000	-57.281	-73.213
60.000	-25.813	-90.000	-57.947	-73.273
61.000	-27.034	-90.000	-59.004	-73.334
62.000	-28.779	-90.000	-60.592	-73.394
63.000	-31.342	-90.000	-63.004	-73.453
64.000	-35.501	-90.000	-67.020	-73.510
65.000	-44.958	-90.000	-76.336	-73.567
66.000	-44.274	90.000	-75.521	106.377

TABLE 5 - CONTINUED

67.000	-34.742	90.000	-65.862	106.323
68.000	-30.232	90.000	-61.231	106.269
69.000	-27.261	90.000	-58.144	106.218
70.000	-25.060	90.000	-55.834	106.167
71.000	-23.333	90.000	-54.004	106.118
72.000	-21.931	90.000	-52.502	106.071
73.000	-20.766	90.000	-51.246	106.026
74.000	-19.787	90.000	-50.180	105.983
75.000	-18.958	90.000	-49.268	105.942
76.000	-18.251	90.000	-48.486	105.903
77.000	-17.650	90.000	-47.814	105.866
78.000	-17.139	90.000	-47.238	105.832
79.000	-16.709	90.000	-46.747	105.800
80.000	-16.349	90.000	-46.333	105.770
81.000	-16.055	90.000	-45.989	105.743
82.000	-15.819	90.000	-45.708	105.719
83.000	-15.637	90.000	-45.488	105.697
84.000	-15.506	90.000	-45.323	105.678
85.000	-15.423	90.000	-45.212	105.662
86.000	-15.385	90.000	-45.150	105.649
87.000	-15.392	90.000	-45.139	105.639
88.000	-15.440	90.000	-45.174	105.632
89.000	-15.531	90.000	-45.256	105.627
90.000	-300.000	0.000	-300.000	0.000
0.000	12.513	90.000	-77.694	-88.649
1.000	12.474	90.000	-91.298	-81.895
2.000	12.358	90.000	-72.283	149.637
3.000	12.162	90.000	-66.668	149.629
4.000	11.888	90.000	-63.270	149.508
5.000	11.534	90.000	-60.893	149.368
6.000	11.098	90.000	-59.167	149.224
7.000	10.578	90.000	-57.791	149.077
8.000	9.973	90.000	-56.877	148.930
9.000	9.279	90.000	-56.175	148.783
10.000	8.493	90.000	-55.759	148.637
11.000	7.611	90.000	-55.544	148.490
12.000	6.629	90.000	-55.516	148.343
13.000	5.540	90.000	-55.680	148.195
14.000	4.340	90.000	-56.040	148.047
15.000	3.020	90.000	-56.574	147.899
16.000	1.571	90.000	-57.292	147.750
17.000	-0.015	90.000	-58.194	147.600
18.000	-1.750	90.000	-59.285	147.449
19.000	-3.645	90.000	-60.576	147.298
20.000	-5.713	90.000	-62.072	147.146
21.000	-7.961	90.000	-63.779	146.993
22.000	-10.388	90.000	-65.694	146.838
23.000	-12.973	90.000	-67.791	146.683
24.000	-15.652	90.000	-70.005	146.526
25.000	-18.275	90.000	-72.185	146.368
26.000	-20.572	90.000	-74.059	146.210
27.000	-22.171	90.000	-75.255	146.050
28.000	-22.785	90.000	-75.481	145.888
29.000	-22.434	90.000	-74.760	145.725
30.000	-21.436	90.000	-73.407	145.561
31.000	-20.157	90.000	-71.786	145.396
32.000	-18.851	90.000	-70.152	145.229
33.000	-17.658	90.000	-68.643	145.061
34.000	-16.635	90.000	-67.317	144.891
35.000	-15.803	90.000	-66.193	144.720
36.000	-15.161	90.000	-65.271	144.547
37.000	-14.706	90.000	-64.544	144.374
38.000	-14.425	90.000	-64.002	144.198
39.000	-14.310	90.000	-63.637	144.022
40.000	-14.353	90.000	-63.437	143.844
41.000	-14.547	90.000	-63.397	143.665

TABLE 5 - CONTINUED

42.000	-14.886	90.000	-63.510	143.485
43.000	-15.364	90.000	-63.771	143.303
44.000	-15.978	90.000	-64.174	143.120
45.000	-16.721	90.000	-64.715	142.936
46.000	-17.587	90.000	-65.386	142.751
47.000	-18.567	90.000	-66.177	142.566
48.000	-19.646	90.000	-67.073	142.379
49.000	-20.796	90.000	-68.048	142.192
50.000	-21.979	90.000	-69.061	142.005
51.000	-23.133	90.000	-70.052	141.817
52.000	-24.174	90.000	-70.936	141.629
53.000	-24.996	90.000	-71.606	141.441
54.000	-25.491	90.000	-71.955	141.253
55.000	-25.580	90.000	-71.902	141.066
56.000	-25.244	90.000	-71.430	140.879
57.000	-24.533	90.000	-70.588	140.692
58.000	-23.542	90.000	-69.471	140.508
59.000	-22.378	90.000	-68.186	140.324
60.000	-21.132	90.000	-66.824	140.142
61.000	-19.871	90.000	-65.451	139.961
62.000	-18.640	90.000	-64.113	139.782
63.000	-17.464	90.000	-62.835	139.606
64.000	-16.359	90.000	-61.631	139.433
65.000	-15.331	90.000	-60.508	139.263
66.000	-14.381	90.000	-59.469	139.095
67.000	-13.509	90.000	-58.510	138.932
68.000	-12.711	90.000	-57.630	138.772
69.000	-11.983	90.000	-56.825	138.617
70.000	-11.322	90.000	-56.090	138.466
71.000	-10.725	90.000	-55.423	138.319
72.000	-10.187	90.000	-54.818	138.179
73.000	-9.703	90.000	-54.273	138.044
74.000	-9.272	90.000	-53.783	137.914
75.000	-8.891	90.000	-53.346	137.791
76.000	-8.554	90.000	-52.959	137.674
77.000	-8.262	90.000	-52.619	137.564
78.000	-8.011	90.000	-52.324	137.461
79.000	-7.800	90.000	-52.072	137.365
80.000	-7.625	90.000	-51.861	137.276
81.000	-7.487	90.000	-51.689	137.195
82.000	-7.382	90.000	-51.554	137.122
83.000	-7.310	90.000	-51.457	137.058
84.000	-7.270	90.000	-51.394	137.001
85.000	-7.262	90.000	-51.366	136.953
86.000	-7.283	90.000	-51.371	136.914
87.000	-7.334	90.000	-51.410	136.883
88.000	-7.414	90.000	-51.481	136.861
89.000	-7.523	90.000	-51.585	136.847
90.000	-292.626	0.000	-292.626	0.000
0.000	12.512	90.000	-75.745	-89.095
1.000	12.474	90.000	-84.827	-84.732
2.000	12.357	90.000	-72.190	-170.519
3.000	12.162	90.000	-68.514	-170.665
4.000	11.887	90.000	-66.341	-170.887
5.000	11.533	90.000	-64.878	-171.121
6.000	11.096	90.000	-63.875	-171.359
7.000	10.576	90.000	-63.135	-171.598
8.000	9.970	90.000	-62.732	-171.839
9.000	9.274	90.000	-62.500	-172.079
10.000	8.487	90.000	-62.490	-172.320
11.000	7.603	90.000	-62.649	-172.561
12.000	6.618	90.000	-62.966	-172.804
13.000	5.524	90.000	-63.449	-173.048
14.000	4.316	90.000	-64.103	-173.292
15.000	2.985	90.000	-64.917	-173.537
16.000	1.518	90.000	-65.904	-173.783

TABLE 5 - CONTINUED

17.000	-0.096	90.000	-67.070	-174.032
18.000	-1.875	90.000	-68.428	-174.282
19.000	-3.840	90.000	-69.998	-174.533
20.000	-6.018	90.000	-71.804	-174.785
21.000	-8.446	90.000	-73.881	-175.040
22.000	-11.169	90.000	-76.272	-175.296
23.000	-14.252	90.000	-79.040	-175.554
24.000	-17.783	90.000	-82.272	-175.814
25.000	-21.875	90.000	-86.080	-176.076
26.000	-26.652	90.000	-90.587	-176.340
27.000	-32.102	90.000	-95.779	-176.606
28.000	-37.373	90.000	-100.804	-176.875
29.000	-39.517	90.000	-102.713	-177.145
30.000	-37.091	90.000	-100.065	-177.418
31.000	-33.192	90.000	-95.951	-177.693
32.000	-29.723	90.000	-92.277	-177.970
33.000	-26.987	90.000	-89.344	-178.251
34.000	-24.899	90.000	-87.068	-178.533
35.000	-23.339	90.000	-85.328	-178.818
36.000	-22.215	90.000	-84.032	-179.105
37.000	-21.461	90.000	-83.112	-179.394
38.000	-21.031	90.000	-82.523	-179.686
39.000	-20.898	90.000	-82.238	-179.979
40.000	-21.050	90.000	-82.243	179.724
41.000	-21.488	90.000	-82.541	179.426
42.000	-22.229	90.000	-83.148	179.125
43.000	-23.314	90.000	-84.104	178.822
44.000	-24.819	90.000	-85.485	178.519
45.000	-26.891	90.000	-87.438	178.212
46.000	-29.845	90.000	-90.278	177.904
47.000	-34.531	90.000	-94.855	177.595
48.000	-45.337	90.000	-105.555	177.285
49.000	-42.538	-90.000	-102.656	-3.027
50.000	-34.205	-90.000	-94.226	-3.339
51.000	-30.362	-90.000	-90.291	-3.652
52.000	-28.017	-90.000	-87.856	-3.965
53.000	-26.468	-90.000	-86.222	-4.278
54.000	-25.441	-90.000	-85.114	-4.591
55.000	-24.804	-90.000	-84.399	-4.903
56.000	-24.486	-90.000	-84.006	-5.214
57.000	-24.453	-90.000	-83.900	-5.525
58.000	-24.693	-90.000	-84.072	-5.833
59.000	-25.217	-90.000	-84.530	-6.140
60.000	-26.058	-90.000	-85.308	-6.443
61.000	-27.286	-90.000	-86.477	-6.744
62.000	-29.041	-90.000	-88.175	-7.042
63.000	-31.620	-90.000	-90.698	-7.335
64.000	-35.811	-90.000	-94.838	-7.624
65.000	-45.415	-90.000	-104.390	-7.908
66.000	-44.327	90.000	-103.256	171.814
67.000	-34.927	90.000	-93.811	171.541
68.000	-30.448	90.000	-89.289	171.275
69.000	-27.491	90.000	-86.291	171.016
70.000	-25.300	90.000	-84.062	170.765
71.000	-23.581	90.000	-82.306	170.521
72.000	-22.184	90.000	-80.875	170.286
73.000	-21.025	90.000	-79.684	170.061
74.000	-20.051	90.000	-78.680	169.845
75.000	-19.225	90.000	-77.825	169.640
76.000	-18.522	90.000	-77.097	169.445
77.000	-17.925	90.000	-76.474	169.261
78.000	-17.417	90.000	-75.944	169.090
79.000	-16.989	90.000	-75.495	168.930
80.000	-16.632	90.000	-75.120	168.782
81.000	-16.340	90.000	-74.810	168.648
82.000	-16.106	90.000	-74.561	168.526

TABLE 5 - CONTINUED

83.000	-15.926	90.000	-74.367	168.418
84.000	-15.796	90.000	-74.226	168.324
85.000	-15.714	90.000	-74.135	168.244
86.000	-15.678	90.000	-74.090	168.178
87.000	-15.685	90.000	-74.091	168.126
88.000	-15.734	90.000	-74.136	168.090
89.000	-15.825	90.000	-74.224	168.068
90.000	-300.000	0.000	-300.000	0.000
0.000	12.512	90.000	-73.796	-89.540
1.000	12.473	90.000	-78.357	-87.570
2.000	12.357	90.000	-72.098	-130.674
3.000	12.161	90.000	-70.359	-130.959
4.000	11.886	90.000	-69.413	-131.281
5.000	11.531	90.000	-68.862	-131.610
6.000	11.094	90.000	-68.583	-131.941
7.000	10.573	90.000	-68.478	-132.274
8.000	9.966	90.000	-68.586	-132.607
9.000	9.269	90.000	-68.826	-132.942
10.000	8.479	90.000	-69.224	-133.277
11.000	7.592	90.000	-69.756	-133.613
12.000	6.601	90.000	-70.421	-133.951
13.000	5.498	90.000	-71.227	-134.290
14.000	4.276	90.000	-72.182	-134.631
15.000	2.922	90.000	-73.288	-134.973
16.000	1.421	90.000	-74.560	-135.317
17.000	-0.250	90.000	-76.018	-135.664
18.000	-2.118	90.000	-77.688	-136.013
19.000	-4.227	90.000	-79.613	-136.363
20.000	-6.644	90.000	-81.857	-136.716
21.000	-9.481	90.000	-84.533	-137.072
22.000	-12.947	90.000	-87.849	-137.430
23.000	-17.517	90.000	-92.275	-137.790
24.000	-24.723	90.000	-99.348	-138.154
25.000	-57.356	-90.001	-131.856	41.483
26.000	-26.592	-90.000	-100.973	41.111
27.000	-21.925	-90.000	-96.196	40.739
28.000	-19.736	-90.000	-93.902	40.363
29.000	-18.597	-90.000	-92.665	39.984
30.000	-18.049	-90.000	-92.024	39.602
31.000	-17.878	-90.000	-91.767	39.218
32.000	-17.962	-90.000	-91.767	38.830
33.000	-18.216	-90.000	-91.944	38.438
34.000	-18.574	-90.000	-92.229	38.042
35.000	-18.979	-90.000	-92.566	37.644
36.000	-19.381	-90.000	-92.904	37.242
37.000	-19.733	-90.000	-93.196	36.838
38.000	-19.998	-90.000	-93.404	36.429
39.000	-20.150	-90.000	-93.502	36.019
40.000	-20.174	-90.000	-93.478	35.604
41.000	-20.076	-90.000	-93.332	35.186
42.000	-19.867	-90.000	-93.080	34.766
43.000	-19.572	-90.000	-92.745	34.342
44.000	-19.218	-90.000	-92.353	33.917
45.000	-18.830	-90.000	-91.931	33.488
46.000	-18.433	-90.000	-91.501	33.057
47.000	-18.047	-90.000	-91.085	32.625
48.000	-17.687	-90.000	-90.696	32.190
49.000	-17.363	-90.000	-90.347	31.754
50.000	-17.084	-90.000	-90.044	31.317
51.000	-16.855	-90.000	-89.793	30.879
52.000	-16.680	-90.000	-89.597	30.441
53.000	-16.558	-90.000	-89.458	30.002
54.000	-16.492	-90.000	-89.375	29.564
55.000	-16.481	-90.000	-89.349	29.127
56.000	-16.523	-90.000	-89.377	28.692
57.000	-16.618	-90.000	-89.458	28.257

TABLE 5 - CONTINUED

58.000	-16.763	-90.000	-89.592	27.826
59.000	-16.956	-90.000	-89.775	27.397
60.000	-17.197	-90.000	-90.007	26.972
61.000	-17.483	-90.000	-90.284	26.550
62.000	-17.812	-90.000	-90.605	26.134
63.000	-18.182	-90.000	-90.968	25.723
64.000	-18.590	-90.000	-91.371	25.319
65.000	-19.036	-90.000	-91.810	24.922
66.000	-19.516	-90.000	-92.286	24.532
67.000	-20.029	-90.000	-92.794	24.151
68.000	-20.572	-90.000	-93.334	23.778
69.000	-21.144	-90.000	-93.902	23.416
70.000	-21.742	-90.000	-94.498	23.063
71.000	-22.364	-90.000	-95.116	22.722
72.000	-23.007	-90.000	-95.757	22.394
73.000	-23.668	-90.000	-96.416	22.079
74.000	-24.344	-90.000	-97.091	21.777
75.000	-25.033	-90.000	-97.777	21.489
76.000	-25.729	-90.000	-98.473	21.217
77.000	-26.431	-90.000	-99.173	20.959
78.000	-27.131	-90.000	-99.872	20.719
79.000	-27.825	-90.000	-100.565	20.495
80.000	-28.509	-90.000	-101.248	20.288
81.000	-29.175	-90.000	-101.914	20.100
82.000	-29.816	-90.000	-102.554	19.929
83.000	-30.425	-90.000	-103.162	19.779
84.000	-30.995	-90.000	-103.731	19.646
85.000	-31.517	-90.000	-104.253	19.534
86.000	-31.984	-90.000	-104.720	19.443
87.000	-32.390	-90.000	-105.125	19.370
88.000	-32.728	-90.000	-105.463	19.319
89.000	-32.993	-90.000	-105.728	19.288
90.000	-300.000	0.000	-300.000	0.000
0.000	12.511	90.000	-300.000	0.000
1.000	12.473	90.000	-300.000	0.000
2.000	12.356	90.000	-300.000	0.000
3.000	12.160	90.000	-300.000	0.000
4.000	11.885	90.000	-300.000	0.000
5.000	11.530	90.000	-300.000	0.000
6.000	11.092	90.000	-300.000	0.000
7.000	10.571	90.000	-300.000	0.000
8.000	9.962	90.000	-300.000	0.000
9.000	9.265	90.000	-300.000	0.000
10.000	8.473	90.000	-300.000	0.000
11.000	7.584	90.000	-300.000	0.000
12.000	6.590	90.000	-300.000	0.000
13.000	5.482	90.000	-300.000	0.000
14.000	4.252	90.000	-300.000	0.000
15.000	2.887	90.000	-300.000	0.000
16.000	1.367	90.000	-300.000	0.000
17.000	-0.333	90.000	-300.000	0.000
18.000	-2.247	90.000	-300.000	0.000
19.000	-4.433	90.000	-300.000	0.000
20.000	-6.982	90.000	-300.000	0.000
21.000	-10.056	90.000	-300.000	0.000
22.000	-14.000	90.000	-300.000	0.000
23.000	-19.763	90.000	-300.000	0.000
24.000	-32.870	90.000	-300.000	0.000
25.000	-27.536	-90.000	-300.000	0.000
26.000	-20.633	-90.000	-300.000	0.000
27.000	-17.594	-90.000	-300.000	0.000
28.000	-15.891	-90.000	-300.000	0.000
29.000	-14.873	-90.000	-300.000	0.000
30.000	-14.274	-90.000	-300.000	0.000
31.000	-13.950	-90.000	-300.000	0.000
32.000	-13.815	-90.000	-300.000	0.000

TABLE 5 - CONTINUED

33.000	-13.810	-90.000	-300.000	0.000
34.000	-13.893	-90.000	-300.000	0.000
35.000	-14.029	-90.000	-300.000	0.000
36.000	-14.193	-90.000	-300.000	0.000
37.000	-14.367	-90.000	-300.000	0.000
38.000	-14.532	-90.000	-300.000	0.000
39.000	-14.682	-90.000	-300.000	0.000
40.000	-14.810	-90.000	-300.000	0.000
41.000	-14.917	-90.000	-300.000	0.000
42.000	-15.003	-90.000	-300.000	0.000
43.000	-15.076	-90.000	-300.000	0.000
44.000	-15.143	-90.000	-300.000	0.000
45.000	-15.210	-90.000	-300.000	0.000
46.000	-15.286	-90.000	-300.000	0.000
47.000	-15.380	-90.000	-300.000	0.000
48.000	-15.498	-90.000	-300.000	0.000
49.000	-15.647	-90.000	-300.000	0.000
50.000	-15.835	-90.000	-300.000	0.000
51.000	-16.064	-90.000	-300.000	0.000
52.000	-16.342	-90.000	-300.000	0.000
53.000	-16.670	-90.000	-300.000	0.000
54.000	-17.055	-90.000	-300.000	0.000
55.000	-17.499	-90.000	-300.000	0.000
56.000	-18.007	-90.000	-300.000	0.000
57.000	-18.582	-90.000	-300.000	0.000
58.000	-19.230	-90.000	-300.000	0.000
59.000	-19.958	-90.000	-300.000	0.000
60.000	-20.772	-90.000	-300.000	0.000
61.000	-21.682	-90.000	-300.000	0.000
62.000	-22.702	-90.000	-300.000	0.000
63.000	-23.848	-90.000	-300.000	0.000
64.000	-25.146	-90.000	-300.000	0.000
65.000	-26.631	-90.000	-300.000	0.000
66.000	-28.357	-90.000	-300.000	0.000
67.000	-30.416	-90.000	-300.000	0.000
68.000	-32.969	-90.000	-300.000	0.000
69.000	-36.357	-90.000	-300.000	0.000
70.000	-41.515	-90.000	-300.000	0.000
71.000	-53.753	-90.000	-300.000	0.000
72.000	-48.364	90.000	-300.000	0.000
73.000	-40.717	90.000	-300.000	0.000
74.000	-37.003	90.000	-300.000	0.000
75.000	-34.629	90.000	-300.000	0.000
76.000	-32.941	90.000	-300.000	0.000
77.000	-31.677	90.000	-300.000	0.000
78.000	-30.701	90.000	-300.000	0.000
79.000	-29.934	90.000	-300.000	0.000
80.000	-29.330	90.000	-300.000	0.000
81.000	-28.854	90.000	-300.000	0.000
82.000	-28.484	90.000	-300.000	0.000
83.000	-28.202	90.000	-300.000	0.000
84.000	-27.998	90.000	-300.000	0.000
85.000	-27.861	90.000	-300.000	0.000
86.000	-27.784	90.000	-300.000	0.000
87.000	-27.763	90.000	-300.000	0.000
88.000	-27.794	90.000	-300.000	0.000
89.000	-27.874	90.000	-300.000	0.000
90.000	-300.000	0.000	-300.000	0.000

- 2) Step 2: The reflector pattern is calculated by using the array feed as a single composite feed. The input data are given in Table 6.

TABLE 6

INPUT DATA FOR CALCULATING THE QUADRANT REFLECTOR PATTERNS
(METHOD B)

```

CM:          ***** 19FPX.DAT *****
CM:          --- TILT= 21.6 DEG. ---
CM:          --- AIC ONLY ---
CM: DEFOCUSSED 19 ELEMENTS ARRAY FEED PATTERN
CE:  ARRAY PATTERN OBTAINED FROM RF19F2.DAT
DG:          EDGES ROTATED 90 DEGREES IN AF:

```

1					
3	137.7	3.	3.	0	22

-70.22	78.02
-74.58	74.58
-80.79	67.79
-86.39	60.49
-91.34	52.73
-95.58	44.57
-99.11	36.07
-101.87	27.30
-103.86	18.31
-105.06	9.19
-105.47	0.00
-105.06	-9.19
-103.86	-18.31
-101.87	-27.30
-99.11	-36.07
-95.58	-44.57
-91.34	-52.73
-86.39	-60.49
-80.79	-67.79
-74.58	-74.58
-70.22	-78.02
7.80	0.00

TO:

F	0.	0.						
F	0	0	0	0				
F	F	F	F	0				
T	T	F	0.8					
T	F	F	F	F	F	0.	0.	
F	F	0.	0.					

FD:

0	T									
T	0	T	1	90.	0.	F				
10	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.

91	0.000	12.514	90.000	-300.000	0.000
	1.000	12.476	90.000	-300.000	0.000
	2.000	12.360	90.000	-300.000	0.000
	3.000	12.166	90.000	-300.000	0.000
	4.000	11.894	90.000	-300.000	0.000

(see Table 5.)

.
.
86.000	-27.784	90.000	-300.000	0.000
87.000	-27.763	90.000	-300.000	0.000
88.000	-27.794	90.000	-300.000	0.000
89.000	-27.874	90.000	-300.000	0.000

TABLE 6 - CONTINUED

	90.000	-300.000	0.000	-300.000	0.000
AF: DEFOCUSED SINGLE COMPOSITE FEED					
1					
7.8	7.8	137.7			
0.	0.	0.			
1.	0.				
90.	21.6	90.			
FQ:					
1	15.				
PZ:					
1					
-135.					
-12.	12.	0.05			
F					
PP:					
1					
1	1				
1	2				
XQ:					

The resulting reflector pattern with the correct gain level for the $\phi = -135^\circ$ cut is shown in Figure 7. Note that a good agreement is achieved between the results from the two methods because the reflector is in the far field region of the array feed. It takes 297.9 seconds cpu time for method A and 73.4 seconds cpu time for method B for a pattern with 480 pattern points and grid size $D_x = D_y = 3$ inches.

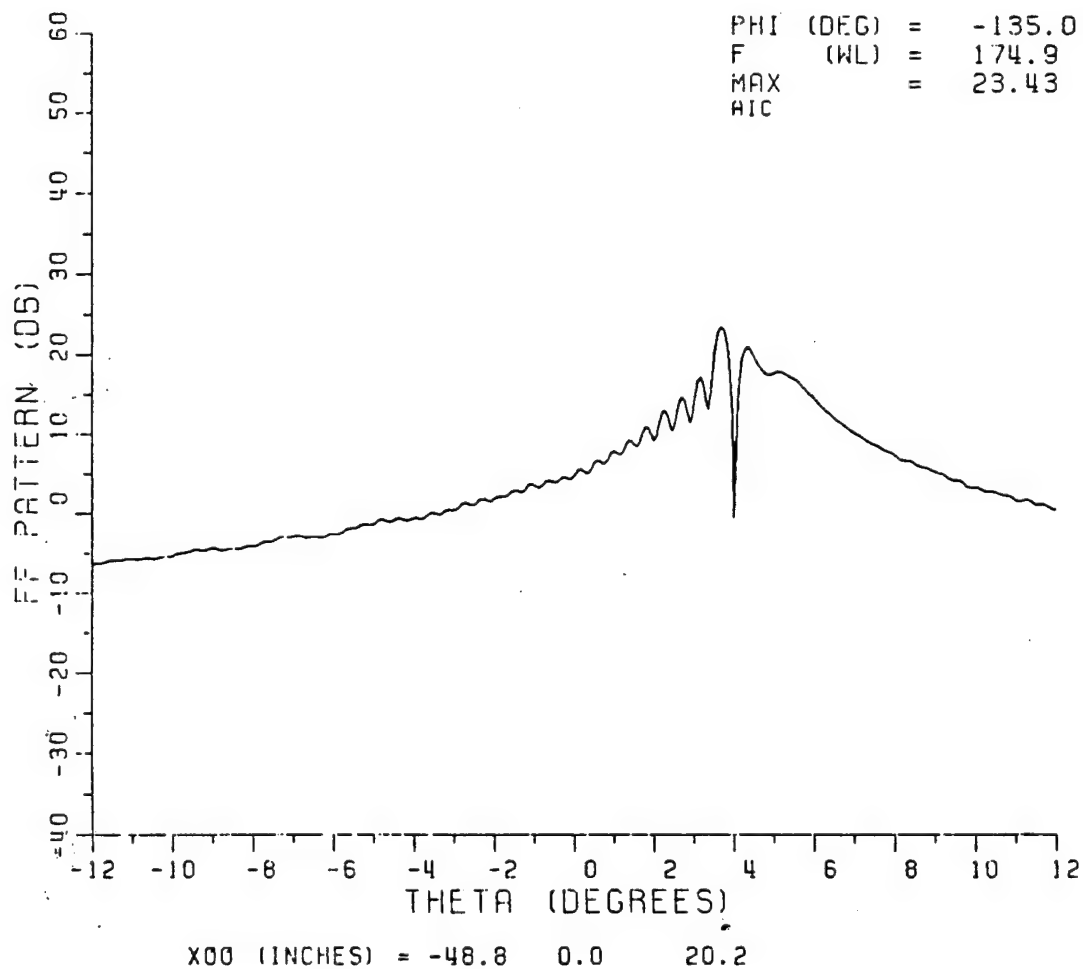
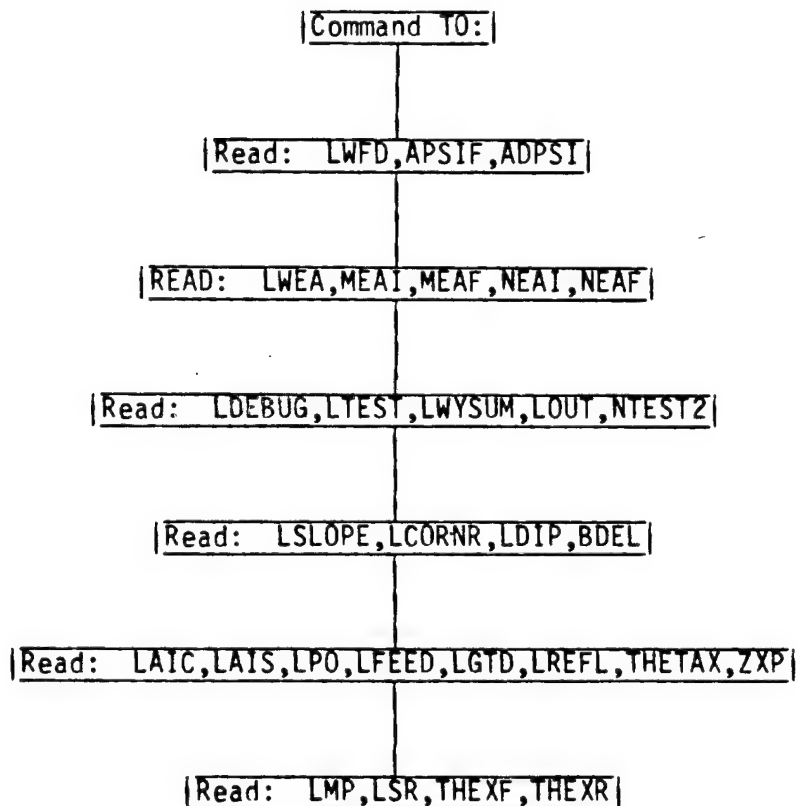


Figure 7. The reflector pattern for the $\phi = -135^\circ$ cut by using method B.

Command T0: BASIC TEST OPTIONS

This command enables the user to obtain an extended output of various intermediate quantities in the computer code. This is useful in testing the program or in analyzing the contributions from various scattering mechanisms in terms of the total solution.

BLOCK DIAGRAM FOR TEST OPTIONS



1. READ: LWFD,APSIF,ADPSI

This read statement is used to output feed pattern data.

- a) LWFD: This logical variable is used to tell the code whether or not to calculate and output data for the feed pattern. (normally set true)
- b) APSIF: This real variable defines the final feed pattern angle (in degrees) for output.
- c) ADPSI: This real variable defines the angle (in degrees) by which output data for the feed pattern is to be incremented.

2. READ: LWEA,MEAI,MEAF,NEAI,NEAF

This read statement is used to output data for the aperture field

- a) LWEA: This logical variable (normally set false) is used to tell the code whether or not to output aperture field data in any rectangular subarray as follows:
- b) MEAI,MEAF: These real variables define the initial and final values of the vertical grid lines to output data for the aperture field.
- c) NEAI,NEAF: These real variables define the initial and final values of the horizontal grid lines to output data for the aperture field.

3. READ: LDEBUG,LTEST,LWYSUM,LOUT,NTEST2

- a) LDEBUG: This logical variable is used to debug the program if errors are suspected within the program. If set true, the program prints out data on unit #6 associated with each of its internal operations. These data can, then, be compared with previous data which are known to be correct. It is also used to insure initial operation of the code. Only one pattern angle is usually considered. (normally set false)

- b) LTEST: This logical variable is used to test key variables in the code such as the input/output associated with each subroutine. The data written out on Unit #6 are associated with the data in the window of the subroutine. They are written out each time the subroutine is called. It is, also, used to insure initial operation of the code. Only one pattern angle is considered. (normally set false)
- c) LWYSUM: This logical variable is used to output data about the aperture field and the partial sums of the aperture integration including the y-integration YSUM data. This data is controlled separately from that controlled by LDEBUG or LTEST because of the large amount of output. (normally set false)
- d) LOUT: This logical variable is used to output data on unit #6 associated with the main program. It is also used to initially insure proper operation. It can be used to examine the various components of the pattern. (normally set false)
- e) NTEST2: This integer variable is used to activate certain write statements for detailed checks or debugging. The value of NTEST2 controls the detailed level to which write statements are activated. Presently, NTEST2=0 unless this command is used.

4. READ: LSLOPE, LCORNR, LDIP, BDEL

These logical variables allow certain GTD diffraction terms to be suppressed for test purposes.

- a) LSLOPE: This logical variable is used to tell the code whether or not slope diffraction is desired during the computation. (normally set true)
- b) LCORNR: This logical variable is used to tell the code whether or not corner diffraction is desired during the computation. (normally set to true)
- c) LDIP: This logical variable is used to tell the code whether or not only the part (DI+) of the GTD diffraction coefficient, which corresponds to the aperture field, is desired during the computation. (normally set false)
- d) BDEL: This real variable is used in the subroutines to adjust the bounds for corner diffraction from the reflector rim. Normally, $0.5 < BDEL < 0.8$; smaller values in this range may improve runtimes, at some loss of accuracy. Presently $BDEL = 0.8$, unless this command is used.

5. READ: LAIC,LAIS,LPO,LFEED,LGTD,LREFL,THETAX,ZXP

- a) LAIC: This logical variable is used to tell the code whether or not conventional aperture integration (AIC) is to be used in computing the pattern. (Normally set true) When NTYPE=10 or 11, LAIC must be false.
- b) LAIS: This logical variable is used to tell the code whether or not the aperture integration on the reflector surface (AIS) is to be used in computing the patterns. (Normally set false)
- c) LPO: This logical variable is used to tell the code whether or not the physical optics (PO) or surface current method is to be used in computing the patterns. (Normally set false)
- d) LFEED: This logical variable is used to tell the code whether or not the primary feed pattern spillover is desired during the pattern computation. (normally set true)
- e) LGTD: This logical variable is used to tell the code whether or not GTD is to be used in computing the pattern. If set false only aperture integration can be used for the contribution from the reflector. (normally set true)
- f) LREFL: This logical variable is used to tell the code whether or not the reflected field from the reflector surface is desired in the pattern computations when LGTD=true. The reflected field from the reflector surface can be obtained by setting LGTD=true, LREFL=true, LMP=false and LSR=false.
- g) THETAX: This real variable, input in degrees, is used as a criterion for switching from AI to GTD for both far field and near field calculations. If the field point angle $|\theta| < \text{THETAX}$, AI is used; otherwise, GTD is used. If THETAX is input as zero or, if no value is input (TO: Command is not used), it will be calculated as follows:

$$\text{THETAX} = \theta_x = \sin^{-1} \frac{1}{\sqrt{A_w}}$$

where A_w is the aperture width in the specific pattern cut.

- h) ZXP: This real variable is input in the units specified by the variable IUNIT in the DG: Command. It is used as a range criterion only for near field calculations. If the range R (LRANG=true) or the distance from the aperture Z (LRANG=false) is less than ZXP, only GTD is used. Otherwise, the near field point angle is compared with THETAX to determine if AI or GTD is used.

The default value of ZXP is zero; thus only AI is used inside the projected aperture unless ZXP is input by the TO: Command.

NOTE: When near field points are calculated within a few aperture widths in front of the aperture, it is recommended to compare both AI and GTD by using the above input parameters. However, AI calculations may not be accurate for points at wide angles outside the projected aperture, or for points closer than two aperture widths. GTD calculations may not be accurate inside or close to the projected aperture for points farther than a few aperture widths, if there are "holes" or extreme variations in the aperture field. The reason for this is that GTD contains only the information for the direct geometrical optics field and the diffracted fields from the rim.

The usage of the above criteria for AI/GTD switching is summarized in the block diagram below:

BLOCK DIAGRAM FOR SWITCHING CRITERIA

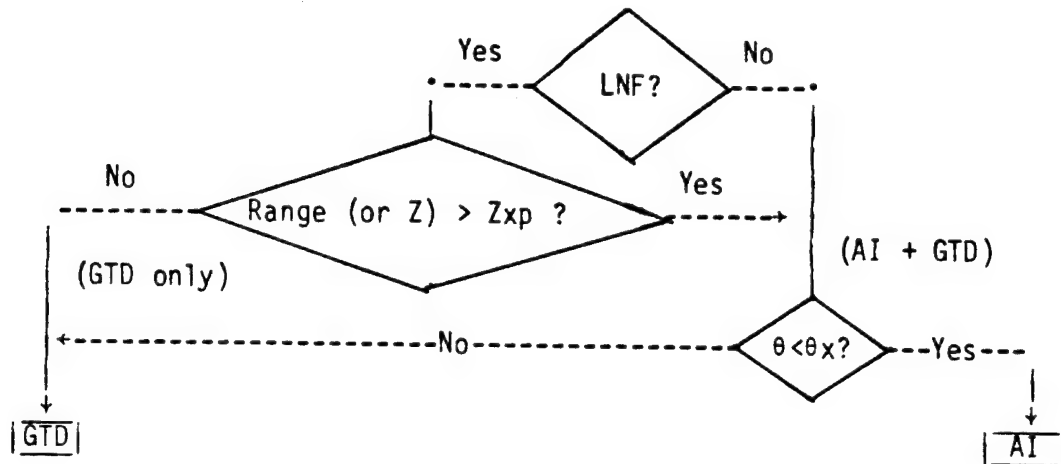
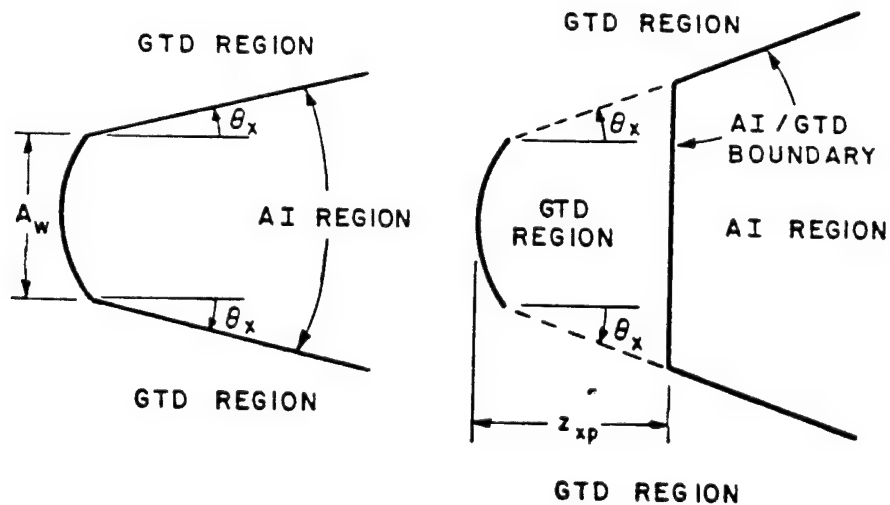


DIAGRAM FOR AI AND GTD REGIONS



a) AI/GTD boundary of the default case (input $\theta_x=0$., $Z_{xp}=0$.)

b) Non-zero Z_{xp} and/or θ_x can be used to decide the AI/GTD boundary.

6. Read: LMP,LSR,THEXF,THEXR

This read statement is used to choose either the Multi-Point GTD or the Segmented-Rim GTD for specified regions.

- a) LMP: This logical variable is used to enable the multi-point GTD. (see Table 1 for details)
- b) LSR: This logical variable is used to enable the segmented rim GTD. (see Table 1 for details)
- c) THEXF: This real variable (θ_{XF}) specifies the switching angle from multi-point GTD to segmented rim GTD in the front axis region if both LMP and LSR are true. If θ_{XF} is input as zero or no value is input (TO: command is not used), it will be set to be 2°.
- d) THEXR: This real variable (θ_{XR}) specifies the switching angle from multi-point GTD to segmented GTD in the rear axis region if both LMP and LSR are true. If θ_{XR} is input as zero or no value is input (TO: command is not used), it will be set to 5°.

NOTE: If there are more than 9 diffraction points found by multi-point GTD (LMP=true), the code will be terminated unless the segmented-rim GTD is also used (i.e., LSR=true).

TABLE 1

THE USE OF LMP AND LSR
TO DETERMINE GTD MODELS USED FOR THE GTD REGION

LMP	LSR	DECISION
F	F	No diffracted field is desired. Spill-over and/or G.O. fields can be obtained if desired.
T	F	Diffracted field is calculated using the multi-point GTD alone. Input for θ_{XF} and θ_{XR} are neglected.
F	T	Diffracted field is calculated using the segmented rim GTD alone. Input for θ_{XF} and θ_{XR} are neglected.
T	T	Diffracted field is calculated using either the multi-point GTD or segmented rim GTD as specified by θ_{XF} and θ_{XR} (see Figure 1).

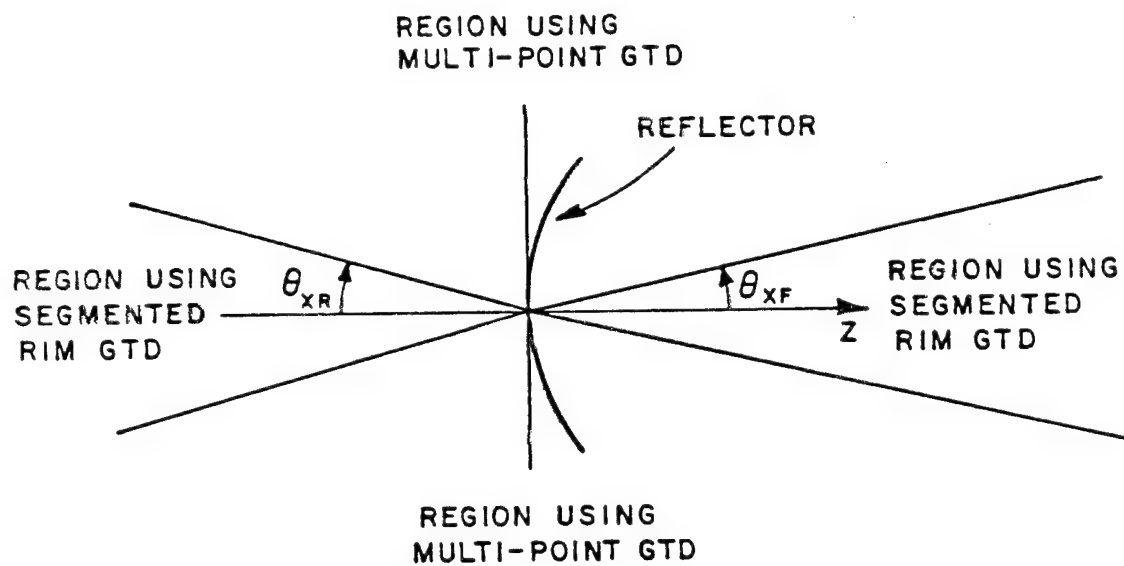
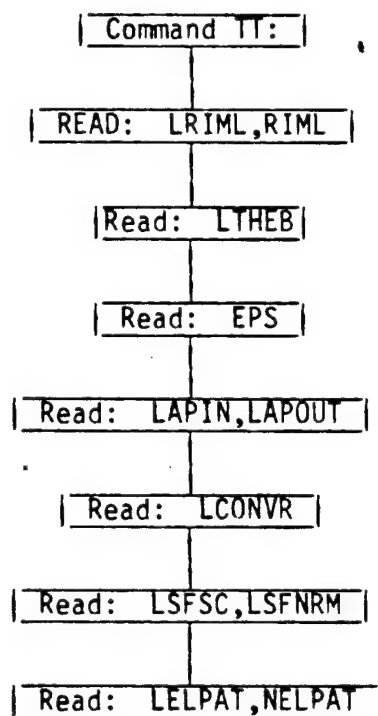


Figure 1. Geometry for switching angles θ_{XF} and θ_{XR} .

Command TT: SPECIAL TEST OPTIONS

This command enables the user to run certain infrequently used tests. CAUTION MUST BE USED IN SELECTING THE VALUES FOR THE FOLLOWING VARIABLES! VALUES SHOULD USUALLY BE IN THE RANGE SPECIFIED.

BLOCK DIAGRAM FOR CERTAIN TESTS



1. Read: LRIML,RIML

- a) LRIML: This logical variable is used to control the maximum length RIML of each segment on the reflector rim. Normally, LRIML is false and RIML is calculated by the code itself. For test purposes, LRIML can be set true; then RIML is read by the next input. (normally set false)
- b) RIML: If LRIML is true, this real variable is used to determine the maximum length (in units) of each rim segment for segmented-rim GTD for far field calculation. For near field calculation, the maximum size is halved, i.e., twice many rim segments are used. If LRIML is false, this input is ignored by the code.

2. Read: LTHER

- a) LTHER: This logical variable is used to decide if the shadow effect of the reflector surface on the diffracted field from the opposite side of the reflector rim should be included. If LTHER is true, as that in default data, this shadow effect is included. This may cause discontinuities in the pattern because double diffraction is not included. (normally set true)

3. Read: EPS

- a) EPS: This real variable is used to define the shadow boundary region for the reflected field from the reflector in the near field GTD case. EPS is the distance in wavelength from the shadow boundary. For those points inside this region, the near field values are calculated by linear interpolation from the adjacent points just outside this region. Presently, EPS=0., unless this command is used.

4. Read: LAPIN,LAPOUT

This statement gives the option to store the aperture fields. If the same reflector system is used, one can store the aperture fields on the first run and then use the stored aperture fields for the next run.

- a) LAPIN: This logical variable enables one to read the stored aperture fields from Unit #20. If LAPIN is true, the stored aperture fields are read.
- b) LAPOUT: This logical variable enables one to store the aperture fields. If LAPOUT is true, the aperture fields are stored in Unit #20.

Note that usually LAPIN and LAPOUT are set false because the aperture fields will take a great deal of computer storage space.

5. Read: LCONVR

This logical variable is used to determine whether the output field data will be converted to principal and cross polarization for far-field or near-field constant range case. If LCONVR=F, the output field data will be in θ and ϕ components. Normally, LCONVR=T.

6. Read: LSFSC,LSFNRM

This statement is used for surface perturbation (SP) or surface distortion (SD) cases.

- a) LSFSC: This logical variable specifies whether the scattered field due to surface error is calculated or not. If LSFSC=T, the scattered field will be calculated. If LSFSC=F, the total field from the distorted reflector will be calculated. Normally, LSFSC=F.
- b) LSFNRM: This logical variable specifies whether the surface error is given along the reflector surface normal or along the z-axis. If LSFNRM=T, the surface error input in SP: or SD: Command is along the reflector surface normal. If LSFNRM=F, the surface error is along z-axis.

7. Read: LELPAT,NELPAT

This statement is used to define the element pattern for Aperture Integration. The element pattern is given as $(\cos(\theta/2))^{NELPAT}$.

- a) LELPAT: This logical variable enables one to change the element pattern. The default of LELPAT is false.
- b) NELPAT: This integer variable specifies the power of $\cos(\theta/2)$ to determine the element pattern. Normally, NELPAT=2. If both AI and GTD are used (LAIC=T and LGTD=T in TO:) to calculate reflector patterns, NELPAT will be set to 1 to make better switchover between AI and GTD unless LELPAT=true.

Command TE: TEST APERTURE FIELD

This command enables the user to test the aperture field data at any point on the aperture.

1. Read: LTEA, NTEA

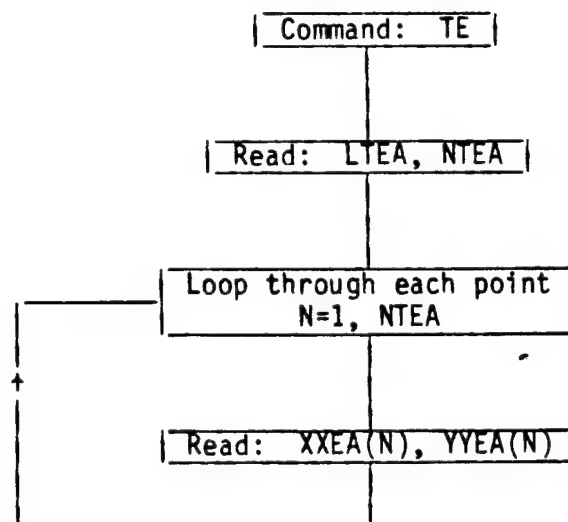
- a) LTEA: This logical variable is used to indicate whether a test for aperture field data is desired.
- b) NTEA: This integer variable is used to specify the number of aperture field points.

2. Read: XXEA(N), YYEA(N)

This read statement is executed NTEA times.

- a) XXEA(N): This dimensional real variable specifies the x coordinate (in units) of the aperture field point to be tested.
- b) YYEA(N): This dimensional real variable specifies the y coordinate (in units) of the aperture field point to be tested.

BLOCK DIAGRAM FOR TEST APERTURE FIELD



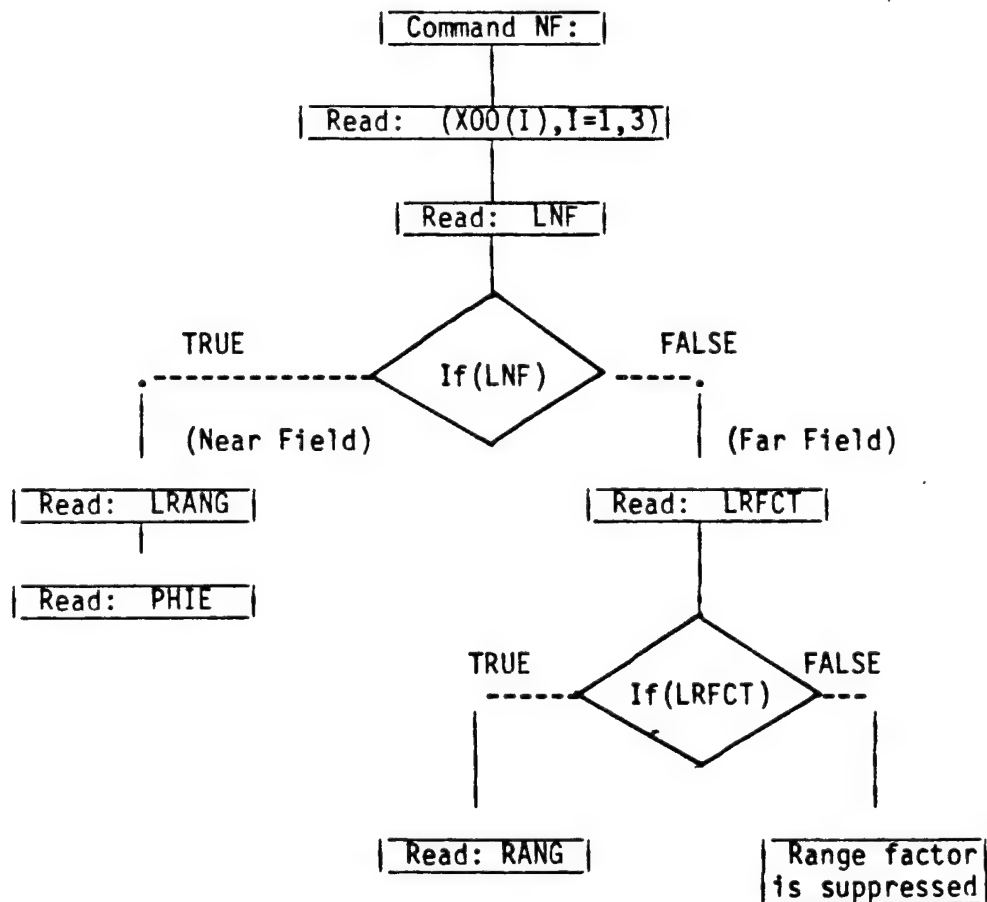
Command NF: NEAR FIELD OUTPUT

This command enables the user to specify whether near field or far field output is to be computed. It also specifies the PHI-plane cut and coordinate origin for near field calculations as shown in Figure 1. The units for the distance parameters are specified according to the value of

IUNIT = < 1->meters
 2->feet
 3->inches.

The value of IUNIT is controlled by the DG: Command.

BLOCK DIAGRAM FOR NEAR FIELD/FAR FIELD OPTIONS



1. READ: (X00(I),I=1,3)

- a) X00(I): This dimensioned real variable is used to specify the origin of the coordinate system for near field observation points. See Figure 1. It is also used to specify a phase reference for the far field pattern. If the NF: Command is not used the default value of X00 = (0,0,ZOP) is used, where ZOP is the distance from the reflector vertex to the aperture plane.

2. READ: LNF

- a) LNF: This logical variable is used to tell the code whether or not near field output is to be computed. If set false, far field patterns are computed.

3. READ: LRFCT

This statement is skipped if LNF=true.

- a) LRFCT: This logical variable specifies whether the range factor is to be included for far field output. If set false, the range factor is suppressed.

4. READ: RANG

This statement is skipped if LNF=true or LRFCT=false.

- a) RANG: This real variable defines the far field range R at which the antenna fields are to be calculated as shown in Figure 1a. It is used only when LRFCT=true and LNF=false.

5. READ: LRANG

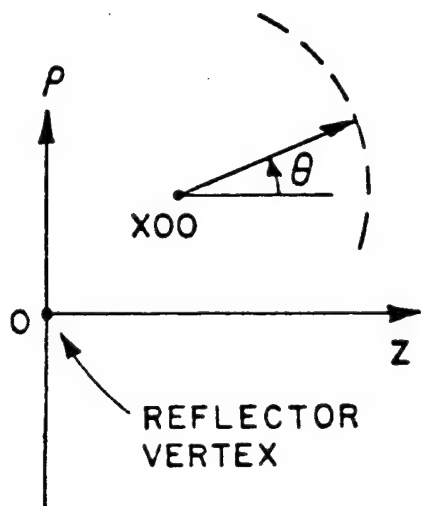
This statement is skipped if LNF=false.

- a) LRANG: This logical variable specifies whether results for a given PHI-plane cut (PHIE) are to be computed for constant range R or constant Z distance from the aperture plane, for near field output. See Figure 1.

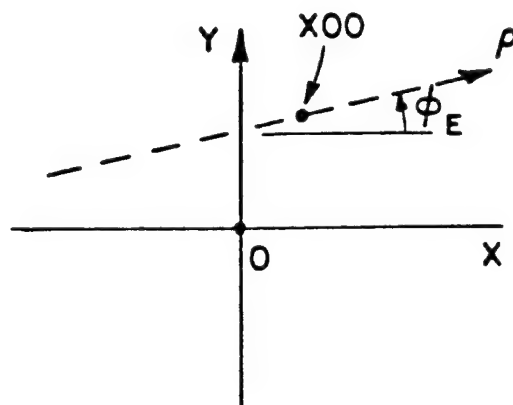
6. READ: PHIE

This statement is skipped if LNF=false.

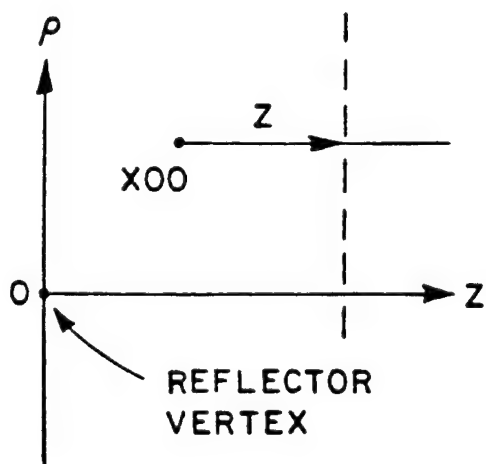
- a) PHIE: This real variable is input in degrees and defines the PHI-plane cut for near field output as shown in Figure 1b.



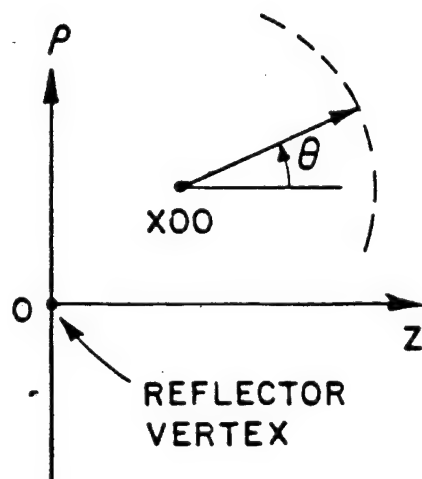
(a) Far Field (LNF=false)



(b) PHIE-plane for Near Field (LNF=true)



(c) Near Field, (LRANG=false)



(d) Near Field, (LRANG=true)

Figure 1. Coordinate systems for far field and near field pattern cuts.

EXAMPLE:

This example illustrates near field calculations with a constant z -cut. The reflector is a circular one with diameter $D=10\lambda$ and an isotropic feed located at a focal distance $F=10,000\lambda$ to simulate a planar aperture. The y component of the near field results as computed by AIC and GTD for the constant plane cut at $Z=12\lambda$ are shown in Figures 2a and b, respectively. Good agreement is achieved by these two methods. The input data for AIC and GTD are given in Table 1 and Table 2, respectively.

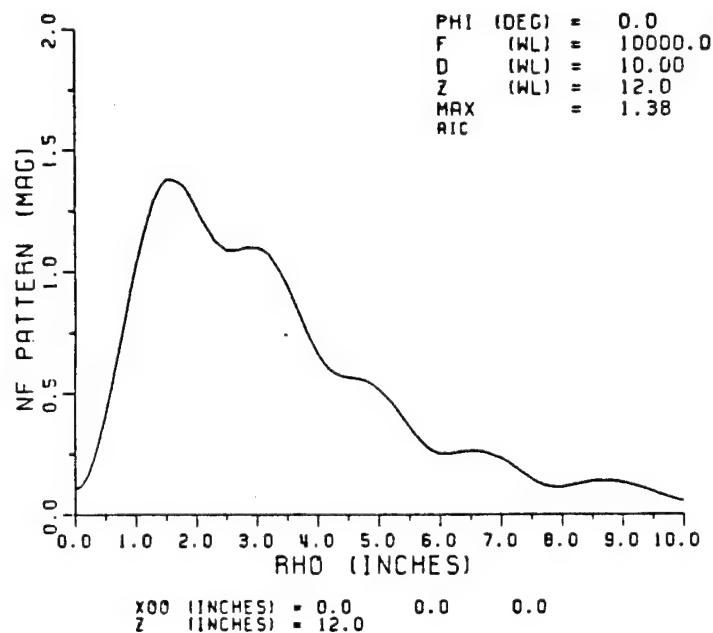


Figure 2a. Near field pattern computed by OSU Reflector Antenna Code using AIC.

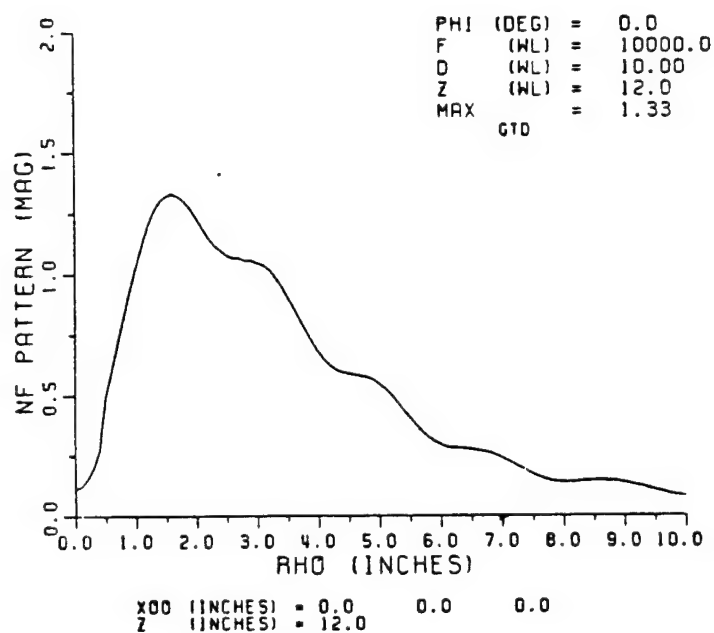


Figure 2b. Near field pattern computed by OSU Reflector Antenna Code using GTD.

TABLE 1

INPUT DATA FOR NEAR FIELD CONSTANT Z-CUT PATTERN CALCULATION (AIC)

```

CM:      ***** PWSAI.DAT *****
CM: NEAR-FIELD WITH CONSTANT Z-CUT
CE:      LAIC = T ONLY
DG:
1
3 10000. 0.2 0.2 10. 0
TO:
F 30. 1.
F 0 0 0 0
F F F F 0
T T F 0.8
T F F F F 0. 0.
F F 0. 0.
FD:
0 T
F 0 F 1 90. 0. F
2 0. 90.
0. 0. 0. 180. 0. 0. 180.
F 180. 180.
FQ:
1 11.81102362
NF:
0. 0. 0.
T
F
0.
PZ:
1
12.
0. 10. 0.1
F
PP:
1
1 1
2 1
XQ:

```

TABLE 2

INPUT DATA FOR NEAR FIELD CONSTANT
Z-CUT PATTERN CALCULATION
(GTD)

```

CM: ' ***** PWSAI.DAT *****
CM: NEAR-FIELD WITH CONSTANT Z-CUT
CE: LGTD = T ONLY
DG:
1
3 10000. 0.2 0.2 10. 0
TO:
F 30. 1.
F 0 0 0 0
F F F F 0
T T F 0.8
F F F F T T 0. 0.
T T 0. 0.
TT:
F 0.
90.
0.04
F F
F
F F
F 0
FD:
0 T
F 0 F 1 90. 0. F
2 0. 90.
0. 0. 0. 180. 0. 0. 180.
F 180. 180.
FQ:
1 11.81102362
NF:
0. 0. 0.
T
F
0.
PZ:
1
12.
0. 10. 0.1
F
PP:
1
1 1
2 1
XQ:

```

Command HZ: RADIATION HAZARD

This command enables the user to output radiation hazard data on the line printer. Regular pattern data is also output. The radiation hazard data includes power density in milliwatts per square centimeter, electric field in volts per meter and near field gain in dB.

1. READ: LRADHZ

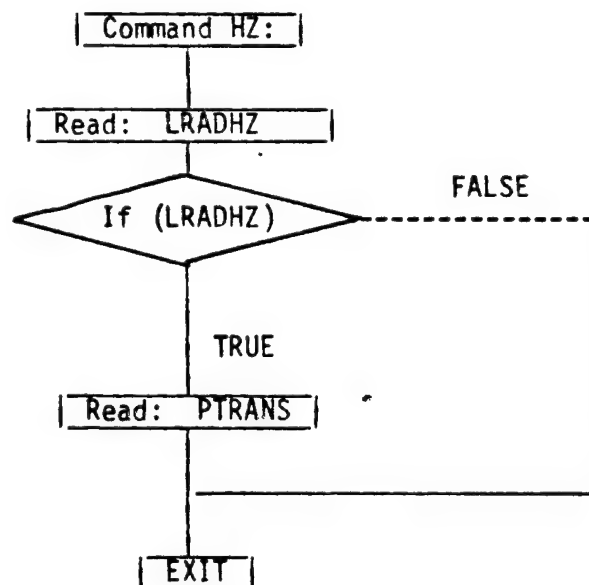
- a) LRADHZ: This logical variable is used to tell the code whether or not radiation hazard data is to be computed. If set false, only regular pattern data is computed.

2. READ: PTRANS

This statement is skipped if LRADHZ=false.

- a) PTRANS: This real variable defines the input power (in watts) to the reflector antenna, which is assumed to radiate all of this power.

BLOCK DIAGRAM FOR RADIATION HAZARD DATA



EXAMPLE:

This example uses a 24" circular reflector and default analytic feed to calculate the output for the radiation hazard applications. The input data are given in Table 1 while the output data are given in Table 2. The power density is calculated in milliwatts per square centimeter, and the electric field is calculated in volts per meter.

TABLE 1
INPUT DATA FOR CALCULATION OF RADIATION HAZARD

```

CM:          ***** C24HZ.DAT *****
CM: GENERAL EXAMPLE OF 24" CIRCULAR REFLECTOR
CE:          NEAR FIELD , RADIATION HAZARD
NF:
0.    0.    4.5
T
T
0.
HZ:
T
1.
PZ:
3
42.9497 107.3742 1073.742
0.    180.    10.
F
XQ:

```

TABLE 2
OUTPUT DATA FOR THE RADIATION HAZARD CALCULATION

```

*****
* XQ:
*
*
*
*
*
*
* FREQUENCY = 11.000 GHZ
*
* WAVELENGTH = 0.027273 METERS
* *THE FOLLOWING DIMENSION UNITS ARE IN WAVELENGTHS *
* * ANGLES & PHASE ARE IN DEGREES *
*
*
* APERTURE DIAMETER = 22.35 WAVELENGTHS
*
* NUMBER OF RIM SEGMENTS=188
*
*
* FOCAL DISTANCE = 7.45
*
* GRIDX = 0.56 GRIDY = 0.56
* RGEOM:RHOS1,BOUND= 11.73480 13.42983
*
* ZOP= 4.191000
* DISTANCE FROM FOCUS TO RIM: RO= 11.642
*
* FEED LOCATED AT ( 0.00, 0.00, 7.45,)
* ( REFERRED TO VERTEX )
*
*
* FEED POWER: PRAD = 0.138E+01
*
* NUMBER OF PRINCIPAL GRID LINES: MMAX= 41 NMAX= 43
*
* APERTURE CENTER AT ( 0.000, 0.000, 4.191 )
*
*
*
*
* CPU TIME FOR APERTURE FIELD CALCULATION = 10.54 SECONDS
*
* THE REFLECTED SHADOW BOUNDARIES IN THE PHIE PLANE ARE AT
*
* RHOS1 = -11.175 AND RHOS2 = 11.175
*
* NEAR FIELD GAIN REFERENCE POINT:
* XREF = ( 0.000, 0.000, 4.191)
* NEAR FIELD GAIN REFERENCE POINT:
* XNREF= ( 0.000, 0.000, 44.191)
*
* RANGE FOR NEAR FIELD GAIN: RANFWL = 0.4000E+02
*
* NEAR FIELD GAIN REF = 24.182
*
* SHADOW BOUNDARY ANGLES: TH1 = 253.74 TH2 = 106.26
* THEB (DEG) = 90.000

```

TABLE 2 - CONTINUED

AI/GTD SWITCHOVER PARAMETERS:

THETAX = 12.22 ZX = 0.000
 NT = 19 P3X = 12.219
 NGTD1 = 0 PG11 = 0.000
 NAI = 3 PAI = 0.000
 NGTD2 = 16 PG21 = 30.000

PHI = 0.00

NEAR FIELD WITH CONSTANT RANGE R = 40.00:
 40.00 FROM APERTURE

PRINCIPAL POL				CROSS POL		
THETA	MAG	DB	PHASE	MAG	DB	PHASE
0.00	0.101E+01	24.29	-33.8	0.766E-07	-118.13	-33.9
10.00	0.347E+00	14.99	163.5	0.263E-07	-127.43	163.9
20.00	0.512E-01	-1.62	23.5	0.366E-08	-144.54	17.9
30.00	0.272E-01	-7.12	-54.8	0.201E-07	-129.77	169.1
40.00	0.179E-01	-10.75	172.6	0.120E-07	-134.27	100.6
50.00	0.156E-01	-11.96	9.3	0.136E-07	-133.17	-12.8
60.00	0.181E-01	-10.64	-162.5	0.608E-08	-140.14	137.5
70.00	0.238E-01	-8.27	-3.3	0.712E-08	-138.76	157.2
80.00	0.206E-01	-9.55	169.2	0.625E-08	-139.89	51.3
90.00	0.276E-01	-7.01	-43.2	0.320E-08	-145.72	162.0
100.00	0.151E-01	-12.26	128.9	0.260E-08	-147.50	102.5
110.00	0.601E-02	-20.24	-159.6	0.523E-08	-141.45	-163.4
120.00	0.299E-02	-26.32	156.0	0.549E-08	-141.03	153.3
130.00	0.185E-02	-30.50	1.8	0.568E-08	-140.73	-0.6
140.00	0.132E-02	-33.42	121.2	0.998E-08	-135.84	153.9
150.00	0.960E-03	-36.17	-176.7	0.605E-08	-140.18	-103.8
160.00	0.105E-02	-35.36	-162.7	0.269E-07	-127.21	174.0
170.00	0.453E-03	-42.70	-137.8	0.144E-07	-132.63	50.9
180.00	0.227E-01	-8.71	-61.5	0.383E-07	-124.15	146.0

***** OUTPUT FOR RADIATION HAZARD *****

TRANSMITTED POWER = 0.1000E+01 WATTS

RANGE = 0.1091E+01 METERS

THETA	E TOTAL (V/m)	POWER DENSITY (mW/cm**2)	NF GAIN (DB)
0.00	0.8227E+02	0.1795E+01	24.29
10.00	0.2820E+02	0.2109E+00	14.99
20.00	0.4164E+01	0.4600E-02	-1.62
30.00	0.2212E+01	0.1298E-02	-7.12
40.00	0.1456E+01	0.5625E-03	-10.75
50.00	0.1267E+01	0.4262E-03	-11.96
60.00	0.1474E+01	0.5764E-03	-10.64
70.00	0.1938E+01	0.9958E-03	-8.27
80.00	0.1672E+01	0.7413E-03	-9.55
90.00	0.2240E+01	0.1331E-02	-7.01
100.00	0.1223E+01	0.3971E-03	-12.26
110.00	0.4882E+00	0.6323E-04	-20.24
120.00	0.2426E+00	0.1561E-04	-26.32
130.00	0.1500E+00	0.5966E-05	-30.50
140.00	0.1071E+00	0.3045E-05	-33.42
150.00	0.7804E-01	0.1615E-05	-36.17
160.00	0.8567E-01	0.1947E-05	-35.36
170.00	0.3680E-01	0.3592E-06	-42.70
180.00	0.1841E+01	0.8994E-03	-8.71

```

THE REFLECTED SHADOW BOUNDARIES IN THE PHIE PLANE ARE AT

      RHOS1 = -11.175      AND RHOS2 = 11.175

NEAR FIELD GAIN REFERENCE POINT:
      XREF = ( 0.000, 0.000, 4.191)
NEAR FIELD GAIN REFERENCE POINT:
      XNREF= ( 0.000, 0.000, 104.192)

RANGE FOR NEAR FIELD GAIN: RANFWL = 0.1000E+03

NEAR FIELD GAIN REF = 32.141

SHADOW BOUNDARY ANGLES: TH1 = 253.74      TH2 = 106.26
THEB (DEG) = 90.000

AI/GTD SWITCHOVER PARAMETERS:
THETAX = 12.22      ZX = 0.000
NT = 19      P3X = 12.219
NGTD1= 0      PG1I= 0.000
NAI = 2      PAI = 0.000
NGTD2= 17     PG2I= 20.000

PHI = 0.00

NEAR FIELD WITH CONSTANT RANGE R = 100.00:
100.00 FROM APERTURE

PRINCIPAL POL                                CROSS POL

THETA      MAG      DB      PHASE      MAG      DB      PHASE
W
W 0.00      0.800E+00    30.20   -22.8    0.606E-07  -112.21  -22.9
W 10.00     0.281E-01     1.11     17.3    0.214E-08  -141.26   16.7
W 20.00     0.134E-01    -5.29     13.7    0.643E-08  -131.69 -168.8
W 30.00     0.100E-01    -7.86    -72.0    0.287E-08  -138.69   86.6
W 40.00     0.913E-02    -8.65    173.7    0.174E-08  -143.06   29.4
W 50.00     0.909E-02    -8.69     17.7    0.230E-08  -140.63  151.1
W 60.00     0.731E-02   -10.58   -156.1    0.209E-08  -141.44  -96.6
W 70.00     0.918E-02    -8.60     27.5    0.205E-08  -141.64 -144.2
W 80.00     0.852E-02    -9.25   -164.5    0.193E-08  -142.14   69.9
W 90.00     0.104E-01    -7.52   -21.8    0.124E-08  -146.00  145.9
W 100.00    0.739E-02   -10.48    161.3    0.130E-08  -145.59  117.6
W 110.00    0.324E-02   -17.66   -91.4    0.214E-08  -141.25  -96.0
W 120.00    0.160E-02   -23.76   -79.0    0.252E-08  -139.85  -82.0
W 130.00    0.975E-03   -28.08  -166.9    0.265E-08  -139.39 -169.3
W 140.00    0.714E-03   -30.78    13.4    0.511E-08  -133.69    0.3
W 150.00    0.593E-03   -32.40   126.9    0.655E-08  -131.54  141.3
W 160.00    0.409E-03   -35.63   163.6    0.548E-08  -133.08  105.2
W 170.00    0.331E-03   -37.46  -125.1    0.117E-07  -126.51  -70.6
W 180.00    0.105E-01    -7.46   -94.3    0.705E-07  -110.90  137.0
W

***** OUTPUT FOR RADIATION HAZARD *****

TRANSMITTED POWER = 0.1000E+01 WATTS

RANGE = 0.2727E+01 METERS

THETA      E TOTAL      POWER DENSITY      NF GAIN
          (V/m)        (mW/cm**2)         (DB)
W
W 0.00      0.6498E+02      0.1120E+01      30.20
W 10.00     0.2281E+01      0.1380E-02       1.11

```

TABLE 2 - CONTINUED

W	20.00	0.1093E+01	0.3168E-03	-5.29	W
W	30.00	0.8127E+00	0.1752E-03	-7.86	W
W	40.00	0.7420E+00	0.1460E-03	-8.65	W
W	50.00	0.7385E+00	0.1447E-03	-8.69	W
W	60.00	0.5938E+00	0.9353E-04	-10.58	W
W	70.00	0.7463E+00	0.1477E-03	-8.60	W
W	80.00	0.6921E+00	0.1271E-03	-9.25	W
W	90.00	0.8450E+00	0.1894E-03	-7.52	W
W	100.00	0.6008E+00	0.9575E-04	-10.48	W
W	110.00	0.2630E+00	0.1835E-04	-17.66	W
W	120.00	0.1302E+00	0.4499E-05	-23.76	W
W	130.00	0.7919E-01	0.1664E-05	-28.08	W
W	140.00	0.5805E-01	0.8938E-06	-30.78	W
W	150.00	0.4818E-01	0.6156E-06	-32.40	W
W	160.00	0.3322E-01	0.2928E-06	-35.63	W
W	170.00	0.2690E-01	0.1920E-06	-37.46	W
W	180.00	0.8504E+00	0.1918E-03	-7.46	W

THE REFLECTED SHADOW BOUNDARIES IN THE PHIE PLANE ARE AT

RHOS1 = -11.175 AND RHOS2 = 11.175

NEAR FIELD GAIN REFERENCE POINT:

XREF = (0.000, 0.000, 4.191)

NEAR FIELD GAIN REFERENCE POINT:

XNREF = (0.000, 0.000, 1004.203)

RANGE FOR NEAR FIELD GAIN: RANFWL = 0.1000E+04

NEAR FIELD GAIN REF = 52.141

SHADOW BOUNDARY ANGLES: TH1 = 253.74 TH2 = 106.26

THEB (DEG) = 90.000

AI/GTD SWITCHOVER PARAMETERS:

THETAX = 12.22 ZX = 0.000

NT = 19 P3X = 12.219

NGTD1 = 0 PG1I = 0.000

NAI = 2 PAI = 0.000

NGTD2 = 17 PG2I = 20.000

PHI = 0.00

NEAR FIELD WITH CONSTANT RANGE R = 1000.01:
1000.01 FROM APERTURE

W	PRINCIPAL POL				CROSS POL			W
	THETA	MAG	DB	PHASE	MAG	DB	PHASE	
W	0.00	0.138E+00	34.93	27.8	0.105E-07	-107.47	27.8	W
W	10.00	0.127E-02	-5.75	159.3	0.996E-10	-147.89	158.5	W
W	20.00	0.273E-03	-19.14	33.7	0.627E-09	-131.92	11.2	W
W	30.00	0.679E-03	-11.22	-60.3	0.340E-09	-137.23	-93.2	W
W	40.00	0.666E-03	-11.39	178.2	0.313E-09	-137.95	148.8	W
W	50.00	0.860E-03	-9.17	34.9	0.194E-09	-142.09	-92.1	W
W	60.00	0.810E-03	-9.69	-146.6	0.167E-09	-143.40	-44.3	W
W	70.00	0.896E-03	-8.81	40.5	0.182E-09	-142.68	-113.7	W
W	80.00	0.870E-03	-9.06	-152.9	0.175E-09	-143.00	73.4	W
W	90.00	0.985E-03	-7.99	-12.3	0.131E-09	-145.50	134.4	W
W	100.00	0.812E-03	-9.67	174.8	0.140E-09	-144.94	120.5	W
W	110.00	0.378E-03	-16.30	-62.2	0.155E-09	-144.04	-67.3	W
W	120.00	0.189E-03	-22.35	-23.6	0.250E-09	-139.89	-26.7	W

TABLE 2 - CONTINUED

W	130.00	0.114E-03	-26.71	-77.2	0.379E-09	-136.30	-66.5	W
W	140.00	0.830E-04	-29.48	137.7	0.474E-09	-134.34	118.8	W
W	150.00	0.712E-04	-30.81	-76.9	0.678E-09	-131.23	-71.5	W
W	160.00	0.435E-04	-35.08	-12.6	0.389E-09	-136.06	-75.0	W
W	170.00	0.431E-04	-35.16	73.9	0.136E-08	-125.17	116.7	W
W	180.00	0.113E-02	-6.82	103.8	0.741E-09	-130.47	-83.8	W

***** OUTPUT FOR RADIATION HAZARD *****

TRANSMITTED POWER = 0.1000E+01 WATTS

RANGE = 0.2727E+02 METERS

W	THETA	E TOTAL (V/m)	POWER DENSITY (mW/cm**2)	NF GAIN (DB)	W
W					W
W					W
W	0.00	0.1121E+02	0.3332E-01	34.93	W
W	10.00	0.1035E+00	0.2843E-05	-5.75	W
W	20.00	0.2216E-01	0.1303E-06	-19.14	W
W	30.00	0.5516E-01	0.8070E-06	-11.22	W
W	40.00	0.5411E-01	0.7767E-06	-11.39	W
W	50.00	0.6987E-01	0.1295E-05	-9.17	W
W	60.00	0.6584E-01	0.1150E-05	-9.69	W
W	70.00	0.7281E-01	0.1406E-05	-8.81	W
W	80.00	0.7073E-01	0.1327E-05	-9.06	W
W	90.00	0.8001E-01	0.1698E-05	-7.99	W
W	100.00	0.6600E-01	0.1156E-05	-9.67	W
W	110.00	0.3074E-01	0.2506E-06	-16.30	W
W	120.00	0.1532E-01	0.6228E-07	-22.35	W
W	130.00	0.9276E-02	0.2282E-07	-26.71	W
W	140.00	0.6746E-02	0.1207E-07	-29.48	W
W	150.00	0.5783E-02	0.8870E-08	-30.81	W
W	160.00	0.3537E-02	0.3319E-08	-35.08	W
W	170.00	0.3506E-02	0.3260E-08	-35.16	W
W	180.00	0.9155E-01	0.2223E-05	-6.82	W

CPU TIME = 45.03 SECONDS

***** OUTPUT LISTING FROM THE OSU REFLECTOR ANTENNA CODE (NASL4) *****

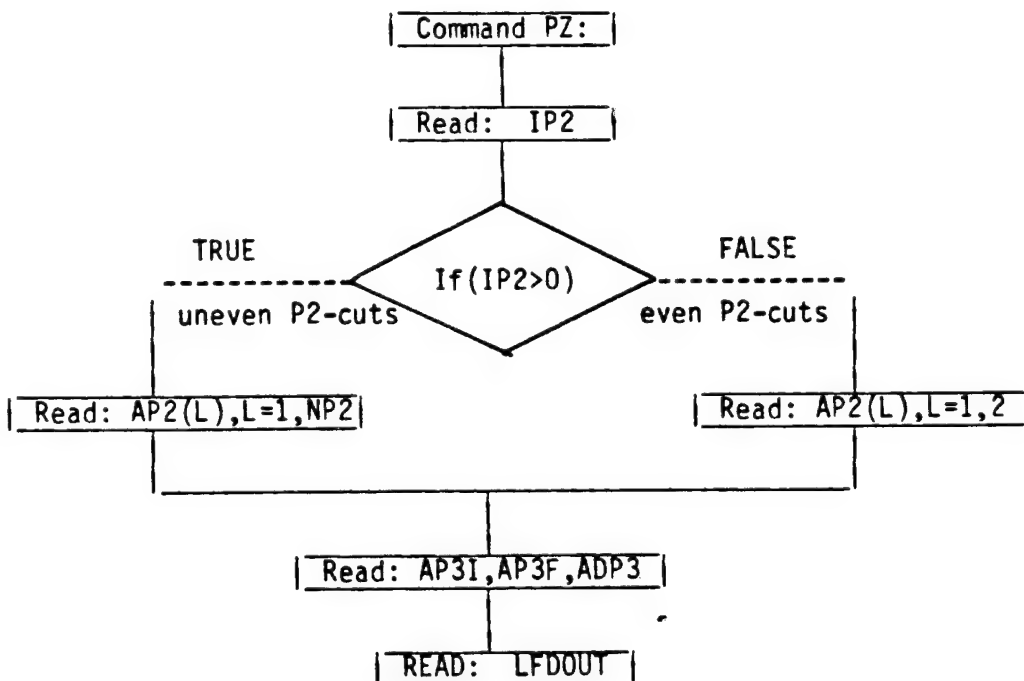
Command PZ: OUTPUT PATTERN POINTS

This command enables the user to specify the output data. For far field patterns (LNF=false) this command specifies the PHI-plane pattern cuts and the initial, final and incremental values for the theta pattern angle. For near field computations this command specifies the constant-range cuts (LRANG=true) or the constant-Z cuts (LRANG=false) for which the fields are to be computed. The output pattern parameters are shown in Table 1. The units for the distance parameters are specified according to the value of

IUNIT = 1->meters
 2->feet
 3->inches.

The value of IUNIT is controlled by the DG: Command.

BLOCK DIAGRAM FOR OUTPUT PATTERN CUTS



The following read statements control the output pattern parameters by use of the variables P2 and P3 as given in Table 1.

1. READ: IP2

- a) IP2: This integer variable is used to specify the number of pattern cuts for the output data for each frequency. Its absolute value $NP2=|IP2|$ is the number of pattern cuts to be calculated. If IP2 is positive ($IP2>0$), unevenly spaced-increments can be used as follows. Presently $1<|IP2|<10$.

2. READ: (AP2(L),L=1,NP2)

- a) AP2(L): This dimensioned real variable defines the Lth value of P2 for output pattern data. This read statement is used only for $IP2>0$.

3. READ: (AP2(L),L=1,2)

This read statement is used for negative values of IP2 ($IP2<0$); then, evenly spaced increments are used as follows:

- a) AP2(L): This is a dimensioned real variable. AP2(1) is the initial value of P2 for the output pattern data. AP2(2) is the P2 increment for the output pattern data.

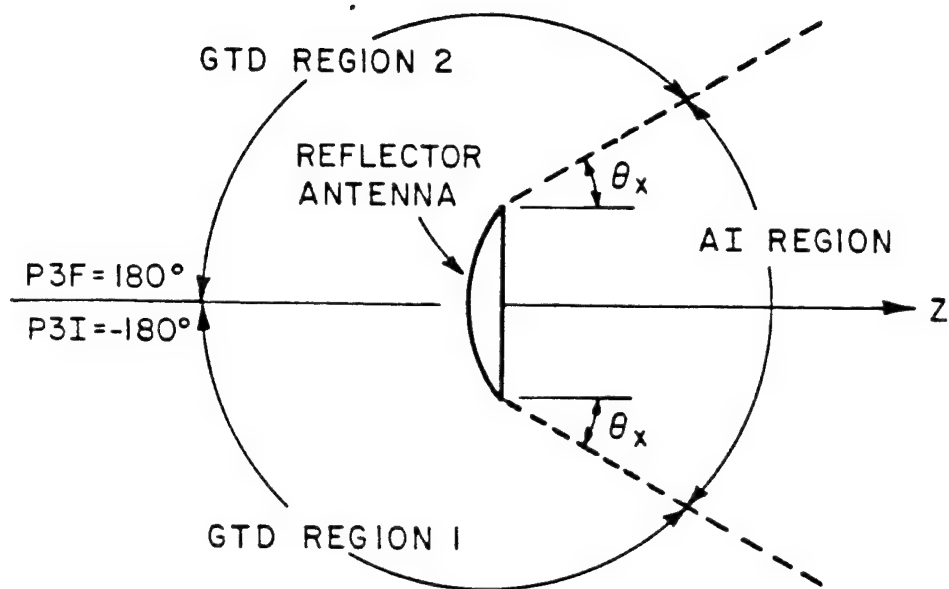
4. READ: AP3I,AP3F,ADP3

- a) AP3I: This real variable defines the initial value of P3 for each pattern cut. $AP3I>-180$ degrees for far field ($LNF=false$).
- b) AP3F: This real variable defines the final value of P3 for each pattern cut. $AP3F<+180$ degrees for far field ($LNF=false$).
- c) ADP3: This real variable defines the value by which P3 is to be incremented for the output pattern. $ADP3>0$.

Two examples of pattern cuts are shown in Figure 1. A constant range case ($LRANG=true$) is shown in Figure 1a for which a full 360 pattern cut is calculated for either far field, ($LNF=false$), or near field, ($LNF=true$) by input of $AP3I=-180$, and $AP3F=180$. A constant-Z example is illustrated in Figure 1b for near field ($LNF=true$) in which AP3I, and AP3F are input in the units specified by IUNIT in the DG: Command.

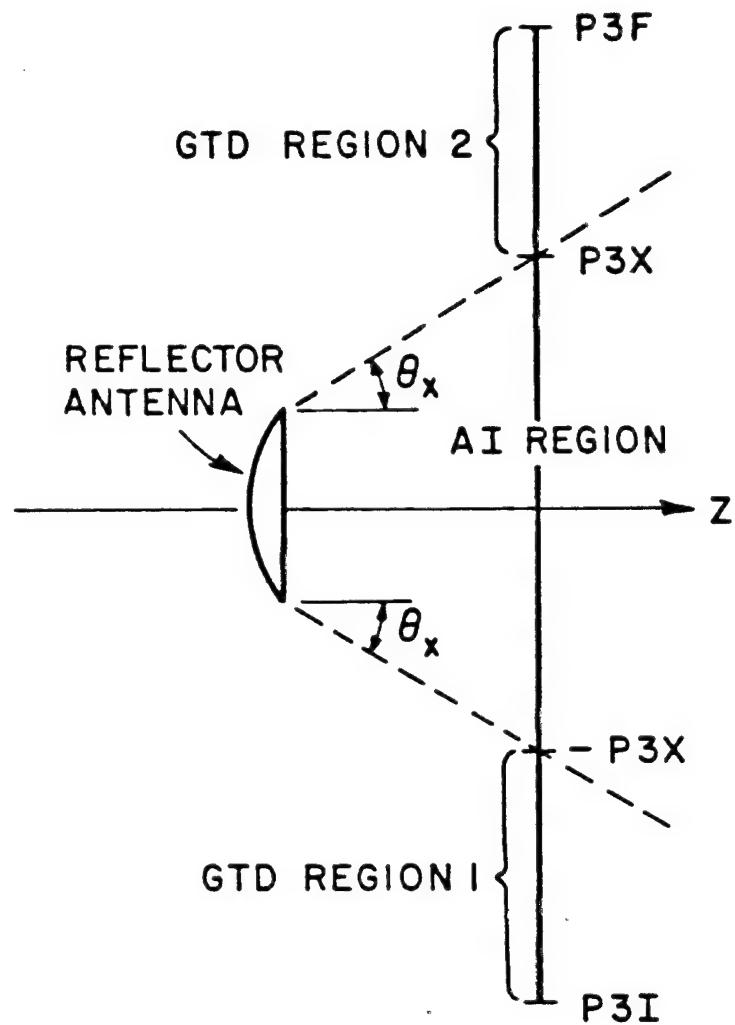
TABLE 1
USE OF VARIABLES P2 AND P3

	P2	P3
Input Variables	AP2(L)	AP3I,AP3F,ADP3
Far Field (LNF=false)	ϕ	θ
Near Field* Constant-R (LRANG=true)	R	θ
Near Field* Constant-Z (LRANG=false)	Z	RHO
*For near field computations the ϕ -plane cut is defined by PHIE as specified by the NF: Command.		



a) Constant range (LRANG=true)

Figure 1. Types of Output Pattern Cuts.



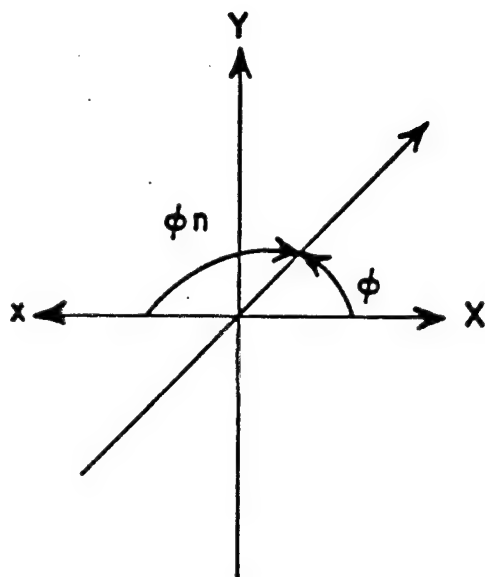
b) Constant Z (LRANG=false)

Figure 1. Continued.

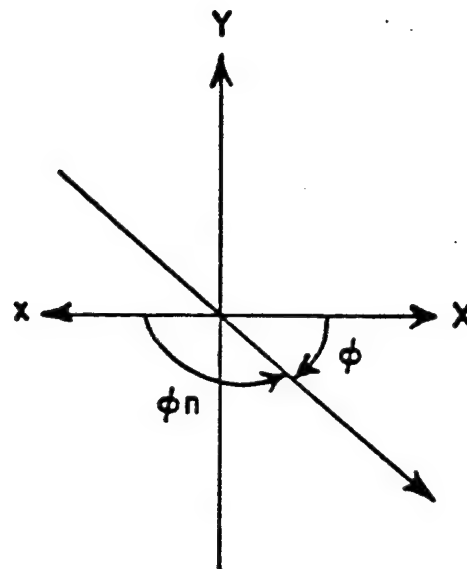
5. Read: LFDOUT

- b) LFDOUT: This logical variable is used to output pattern data on Unit #7 with the same format as that used for feed pattern data in the FD: Command (with LDB=true). Thus, feed pattern data can be directly generated from this code by using one of the following commands: the AP:, WG:, or BR: Command. Two separate runs are needed: one to generate the feed pattern, the second to calculate the reflector pattern. (normally set false)

NOTE: When LFDOUT=true is used to generate the feed data for the next run, the relationship between $P2 (\phi)$ and $PHIN (\phi_n)$ which will be used for the FD: Command in the subsequent run, must be noticed for feed patterns which are unsymmetric with respect to y-axis ($ISYM=0$ or $|ISYM|=2$). This relationship results from the difference between the coordinate systems in the two different runs which is described in Figure 2 where X-Y is the coordinate system of the reflector for the present run and x-y is the coordinate system of the feed for the next run. In other words, the directions of the reflector and feed axes are reversed. If $|ISYM|=1$ or 3, this relationship can be ignored because of symmetry in the feed patterns. Some samples are also shown in Table 2.



$$\phi < \phi_n, \phi_n = 180 - \phi$$



$$\phi < \phi_n, \phi_n = -180 - \phi$$

Input Angle (ϕ): P2 (in the current PZ: Command)

Output feed pattern angle (ϕ_n): PHIN (to be used in the subsequent FD: Command)

Figure 2. Relationship between ϕ and ϕ_n .

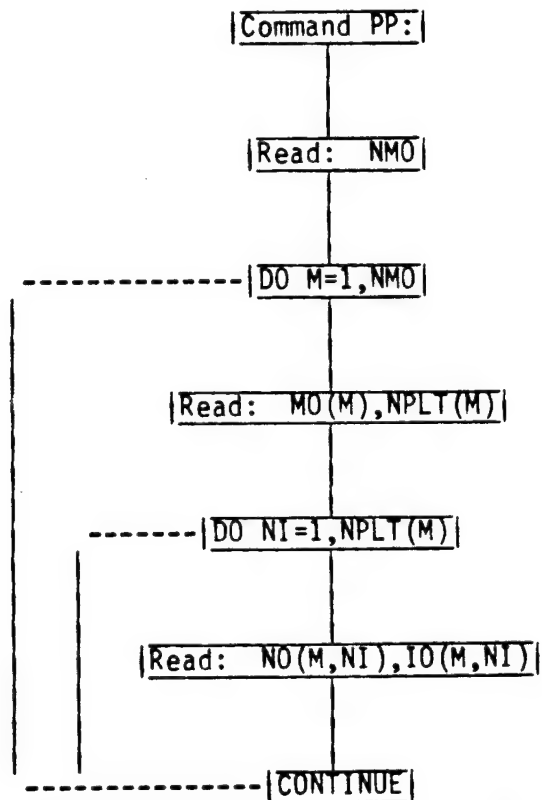
TABLE 2
SAMPLE INPUT ANGLES FOR DESIRED FEED PATTERN ANGLES

Desired Feed Angle	Required Input Angle
PHIN(ϕ_n)	P2(ϕ)
-180.	0.
-135.	- 45.
- 90.	- 90.
- 45.	-135.
0.	180.
45.	135.
90.	90.
135.	45.
180.	0.

Command PP: PLOT RADIATION PATTERN

This command enables the user to specify the plotted data for output patterns of the reflector antenna fields. Other commands are used to plot feed patterns (PF: Command) and Y-integration plots (PY: Command). All plot data for reflector antenna fields are output on Unit #3.

BLOCK DIAGRAM FOR PLOTS OF OUTPUT PATTERNS



1. READ: NMO

- a) NMO: This integer variable specifies the number of field terms for which output patterns are to be plotted. Typically, NMO=1, and MO(1)=1 in the next read statement to plot only the total field. The value of NMO is independent of the number of patterns specified by IP2 in the PZ: Command; each pattern will be plotted with NMO=1. Data for the plots are output on Unit #3.

2. READ: MO(M),NPLT(M)

This read statement is executed NMO times.

- a) MO(M): This integer specifies the field terms to be plotted as follows:

- MO =
- 1 Total field
 - 2 Radiating field from the reflector surface
 - 3 Scattered field from feed blockage
 - 4 Scattered field from the reflector/strut scattering
 - 5 Scattered field from the feed/strut scattering
 - 6 Scattered field from both the reflector/strut and feed/strut scattering
 - 7 Scattered field from cracks

- b) NPLT(M): This integer specifies the number of plots for each field term.

3. READ: NO(M,NI),IO(M,NI)

This read statement is executed NPLT(M) times for each field term.

- a) NO(M,NI): This integer specifies the polarization component to be plotted as follows:

- NO =
- 1 X component (for L_{LANG}=F); or principal polarized component (for L_{LANG}=T)
 - 2 Y component (for L_{LANG}=F); or cross polarized component (for L_{LANG}=T)
 - 3 Z component (for L_{LANG}=F; for near field only)

- b) IO(M,NI): This integer specifies the format to be plotted as follows:

- IO =
- 1 magnitude of a field term.
 - 2 dB value of a field term.
 - 3 phase of a field term in degrees.

 Command LP: LINE PRINTER LISTING

This command enables the user to specify whether a line printer listing of the results is desired. It sets a flag so that data will be written out on a line printer. Line printer data is output on Unit #6.

1. READ: NPRI

- a) NPRI: This integer variable specifies the number of printouts and controls the format of the printout as summarized below:

DATA OUTPUT ON LINE PRINTER		
	Near field with constant-Z plane cut (LRANG=F)	Far field and constant range near field (LRANG=T)
NPRI	X,Y,Z components	Principal and cross polarized components
-1	-----	Field terms for M = 1, 2, 3, 6
1	Total field in magnitude, dB and phase forms.	Total field in magnitude dB and phase forms.
2 or larger	In addition to the total field, the field terms indexed by M=JP(I), I=2, NPRI are printed out in the same format as the total field. (See M values below)	The field terms indexed by M=JP(I), I=1,NPRI are printed out (See M values below)

1 Total field
2 Radiating field from the reflector surface
3 Scattered field from feed blockage
4 Scattered field from the reflector/strut
NO = scattering
5 Scattered field from the feed/strut scattering
6 Scattered field from both the reflector/strut
and feed/strut scattering
7 Scattered field from cracks

2. READ; (JP(I),I=1,NPRI)

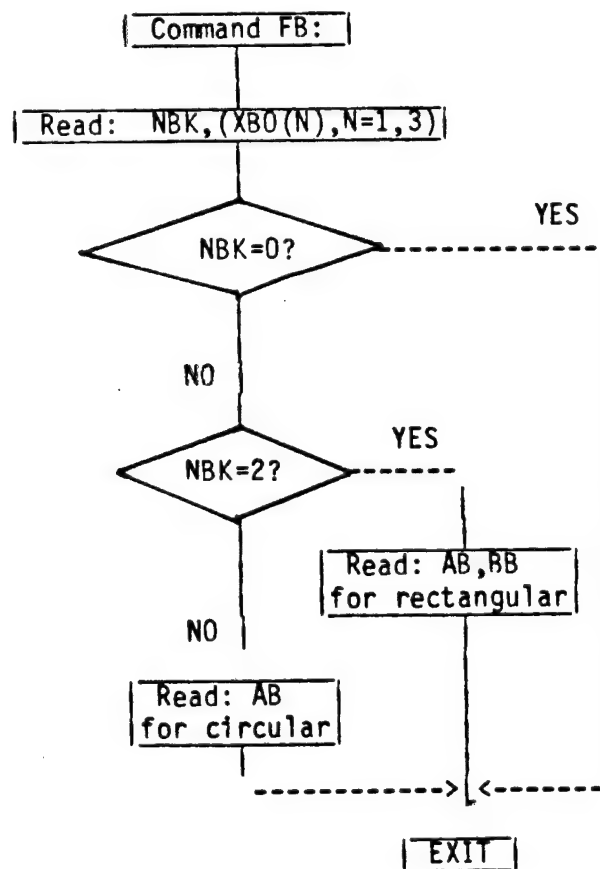
This statement is skipped if LNF=false or NPRI < 2. (LNF is read in NF:)

a) JP(I) The input values for this integer array specify the field terms to be printed out as shown in the table above.

Command FB: FEED BLOCKAGE

This command enables the user to simulate feed blockage by a circular or rectangular flat plate. The units for the distance parameters are specified by the value of the integer IUNIT in the DG: Command.

BLOCK DIAGRAM FOR FEED BLOCKAGE



1. READ: NBK,(XBO(N),N=1,3)

a) NBK: This integer variable is used to specify the feed blockage type as shown in Figure 1.

NBK = 0 No feed blockage

NBK = 1 Circular feed blockage

NBK = 2 Rectangular feed blockage

b) XBO(N): This dimensioned real variable is used to specify the position (in rectangular coordinates) of the center of the feed blockage plate, relative to the reflector vertex as shown in Figure 2.

2. READ: AB

a) AB: This real variable is read when circular feed blockage is desired. It specifies the diameter of the plate.

3. READ: AB,BB

These real variables are read when rectangular feed blockage is desired.

a) AB: The width (in X) of the plate.

b) BB: The height (in Y) of the plate.

NOTE: Feed blockage (FB) is modeled by the far-field approximation of Physical Optics model of a rectangular or circular flat plate. These models will be valid in the main beam and near side lobe region provided that the observation range is located at the far-field of these plates, i.e., the observation range (constant-R or constant-Z in NF:) must be greater than or equal to $2D^2/\lambda$ where D is the maximum dimension of the feed blockage plates.

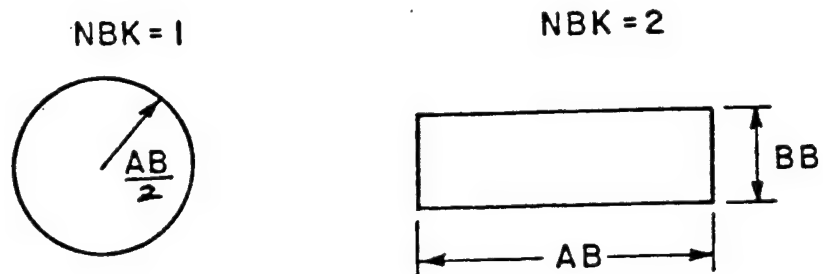


Figure 1. Feed blockage models.

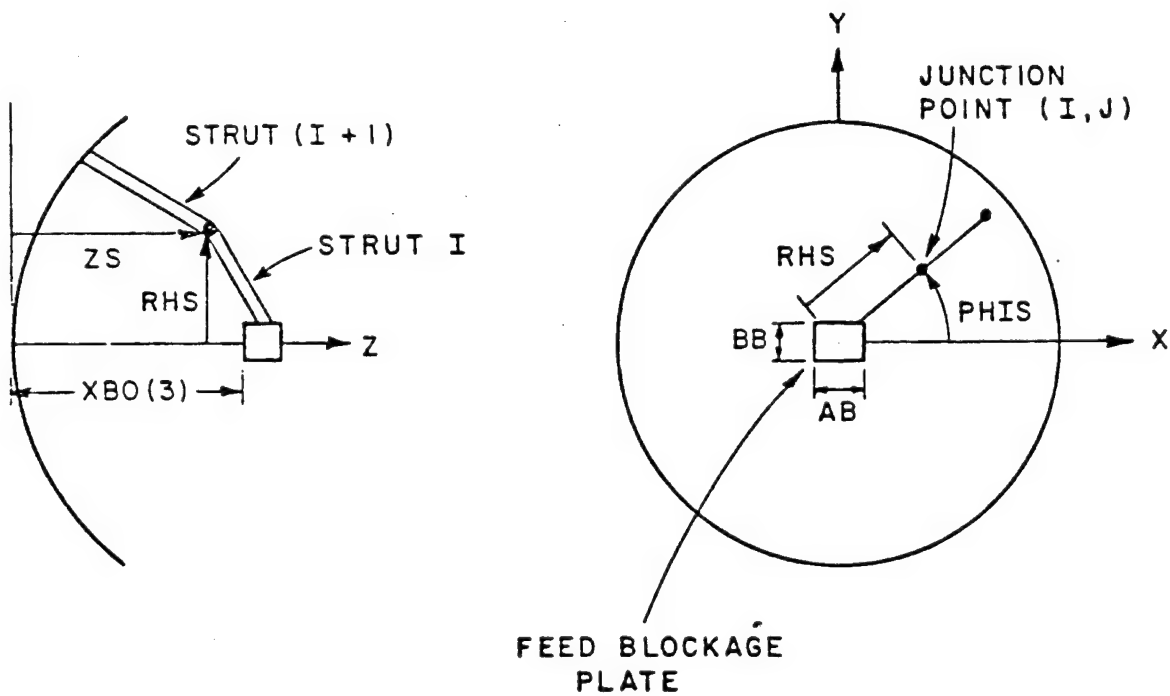


Figure 2. Strut/feed blockage geometries.

Command ST: STRUT SCATTERING

This command enables the user to specify the geometry of the supporting struts of reflector antennas. Two models of the supporting struts are used as shown in Figure 1. For the model shown in Figure 1(a), referred to as reflector/strut scattering, the incident fields on the struts are the reflected fields from the reflector surface. For the one shown in Figure 1(b), referred to as feed/strut scattering, the incident fields are from the primary feed. Each strut can have either circular or general cross section and can be divided into small sections. Each section will be considered as an individual strut inside the code and can be further subdivided into small segments.

The axis of each strut is straight; however, a piecewise linear strut can be modeled by joining several struts at their end-points. In such a case, the coordinates of the end-point at each junction will be input as end-points for both adjacent struts.

1. Read: ISTRUT

- a) ISTRUT: This integer variable specifies the type of strut scattering.

ISTRUT = 0: Reflector/strut scattering, the incident vectors on the strut are assumed to be parallel to the reflector \hat{z} axis.

ISTRUT = 1: Reflector/strut scattering, the incident vectors on the strut are found by a ray tracing technique.

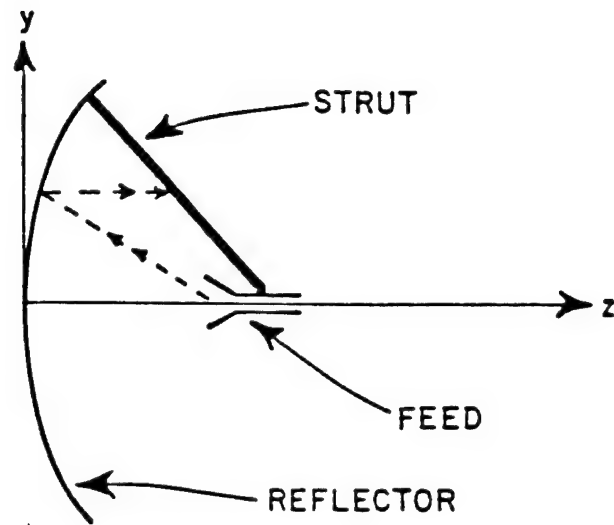
ISTRUT = 2: Feed/strut scattering

ISTRUT = 3: Both reflector/strut and feed/strut scattering

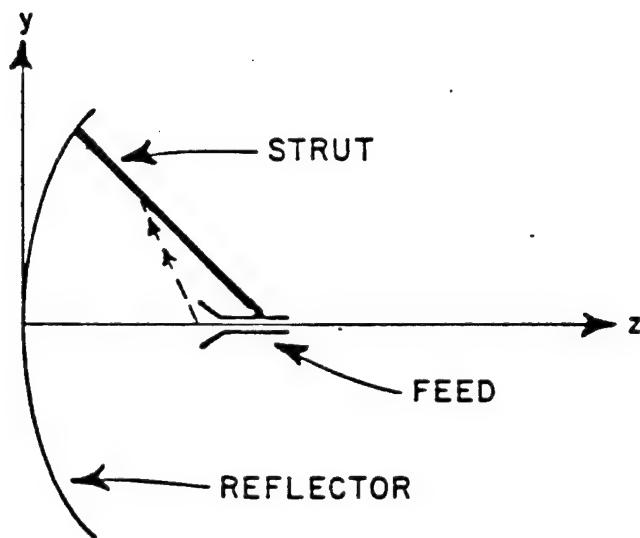
2. Read: NS,GRST,THEST,LGEN,LBSAME,LCSAME,LNSAME

- a) NS: This integer variable specifies the number of struts. Presently, $NS \leq 108$.

- b) GRST: This real variable specifies the size of the segment used in subdividing a section of each strut. The grid size GRST (input in units) controls the number of segments into which each section is subdivided, and should not exceed 0.5 wavelengths. Presently, a maximum of 63 segments can be used on any strut section.



(a) reflector/strut scattering



• (b) feed/strut scattering

Figure 1. Geometry of a reflector with one strut.

- c) THEST: This real variable is used to adjust the maximum theta angle for which strut scattering is included. Normally, $90 < \text{THEST} < 120^\circ$; other values may be used to approximate the shadowing of the strut scattering by the reflector surface. Presently, $\text{THEST} = 100^\circ$, unless this command is used.
- d) LGEN: This logical variable specifies whether the struts have circular or general cross sections. The eigenfunction solution is used for circular cross sections whereas a moment method solution is used for general cross sections. Each strut can be subdivided into sections for the purposes of allowing sufficiently small segments, yet not exceeding the maximum number of segments per section. $\text{LGEN} = \text{F}$ for struts with circular cross section.
- e) LBSAME: This logical variable specifies whether the beta angle (β) for all struts is the same or not. The definition of β is the angle between the incident vector and the unit vector along the axis of the strut at the mid-point of the strut as shown in Figure 2. The unit vector along the strut axis is directed from the first end-point of the strut to the second end-point.
- f) LCSAME: This logical variable specifies whether all the struts have same cross section or not. If LCSAME is true, the strut cross section is input only once.
- g) LNSAME: This logical variable specifies whether all struts are divided into same number of sections or not. (Note that each section can be further subdivided into small segments by the variable GRST).

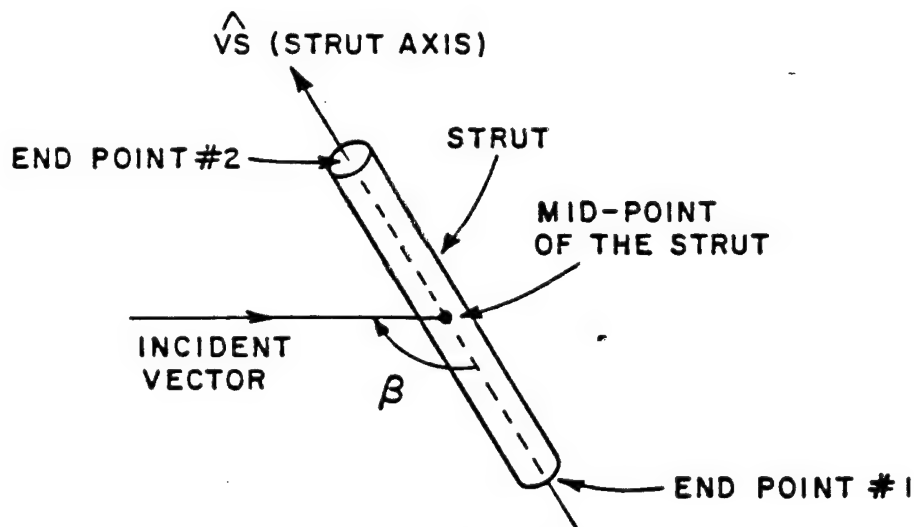


Figure 2. Geometry for the definition of β angle.

3. Read: RHSU,PHIS(M,J),ZSU

This statement is executed twice for the end-points ($J=1,2$) for each strut (strut # M). The coordinate system is cylindrical, referred to the vertex of the reflector as shown in Figure 3.

- a) RHSU: This real variable specifies the rho-coordinate of the J^{th} end point on the M^{th} strut.
- b) PHIS(M,J): This is a real variable specifying the phi-coordinate (in degrees) of the end-points ($J=1,2$) on the M^{th} strut.
- c) ZSU: This is a real variable specifying the Z-coordinate of the J^{th} end-point on the M^{th} strut.

4. Read: NSS(M)

- a) NSS(M): This integer variable specifies the number of sections into which strut M is to be subdivided. (This is useful for struts which are too long to be subdivided into sufficiently small segments because the number of segments would exceed that allowed by the dimensioned variables. Presently, 63 segments are allowed per section.)

If LNSAME=T, this variable is read only for the first strut ($M=1$). Note that the maximum number of subdivided sections for all the struts is 108. An example with 3 strut sections is given in Figure 4.

5. Read: DPU

This statement is executed only for struts with circular cross sections (LGEN=F). If all struts have the same cross section (LCSAME=T), this statement is executed only for the first strut. If LCSAME=F, this statement is executed for each strut.

- a) DPU: This real variable specifies the diameter of the M^{th} strut. Presently, the maximum strut diameter is 10 wavelengths.

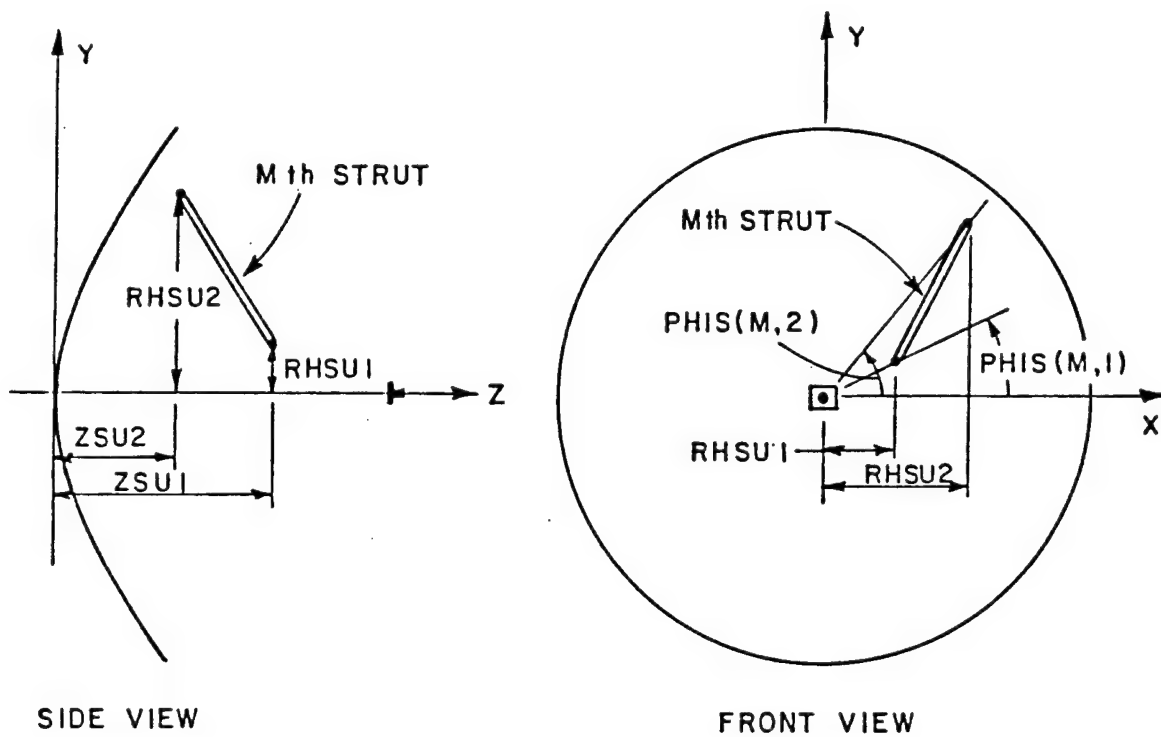


Figure 3. Coordinate system for the end points of the M^{th} strut.

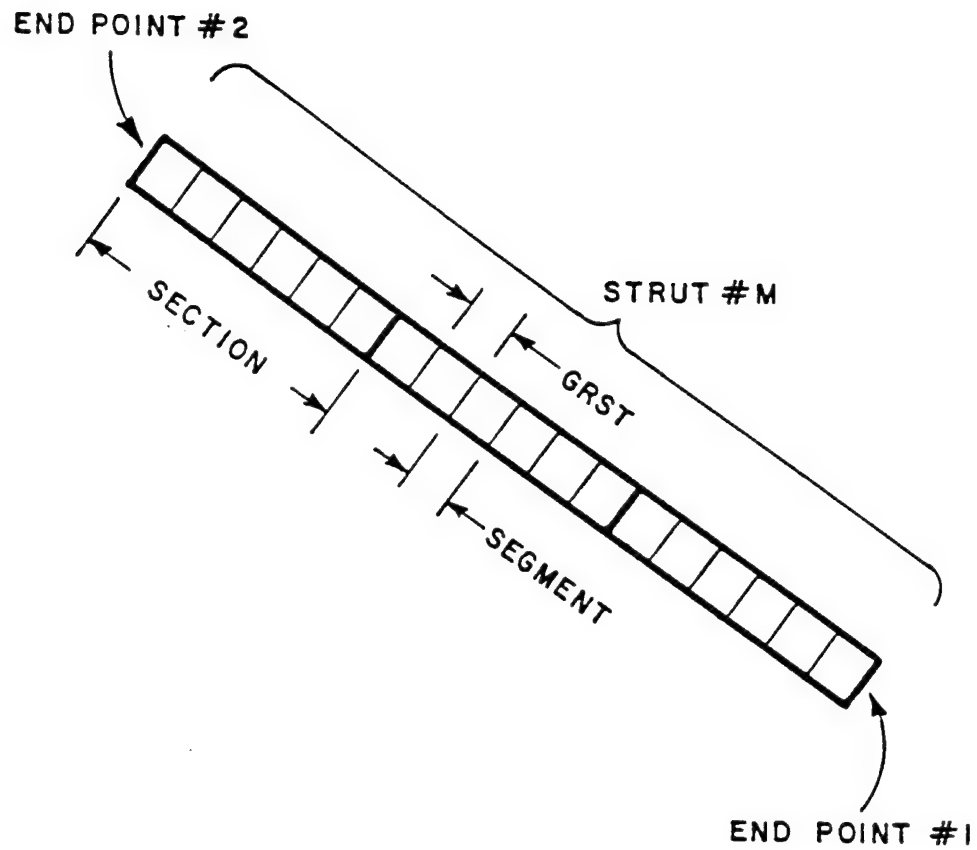


Figure 4. Example of a strut divided into 3 sections $NSS(M)=3$. In this particular example each section is divided into 6 segments by the choice of GRST.

The following statements are executed only for general struts (LGEN=T).

6. Read: TWIST2

If LBSAME=F, this statement is executed for each strut. If LBSAME = T, this statement is executed only for the first strut.

- a) TWIST2: This variable specifies the twist angle of the strut with respect to the X' -axis ($-Z$ axis of the reflector coordinate system for $\beta=90^\circ$) as shown in Figure 5.

7. Read: NM

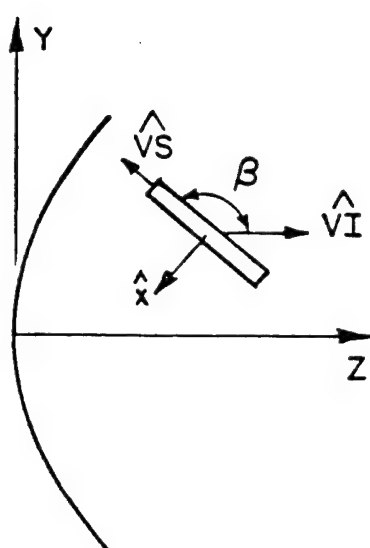
If LCSAME=F, this statement is executed for each strut; if LCSAME=T, this statement is executed for the first strut only.

- a) NM: This integer variable specifies number of points which describe the rim of the cross section of the strut. For struts with rectangular cross section, for example, NM should be at least equal to 4. Points on the line which connects two adjacent points can also be input as shown in Figure 5. A maximum of 10 points can be input for each strut cross section. The length between any two points should not exceed 0.25λ . The coordinates of these points are input in the next statement.

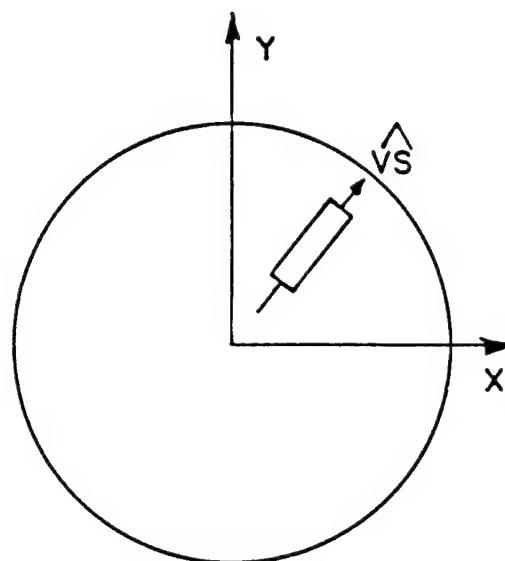
8. Read: XXCS(K), YYCS(K), K=1,NM

This statement is executed when NM is input in the previous read statement.

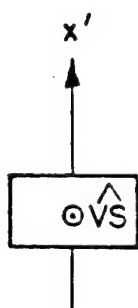
- a) XXCS(K): This dimensioned variable specifies the x-coordinate of the K^{th} point of the rim of the cross section in the local coordinate system of the strut.
- b) YYCS(K): This dimensioned variable specifies the y-coordinate of the K^{th} point of the rim of the cross section in the local coordinate system of the strut. An example of a rectangular strut is given in Figure 6.



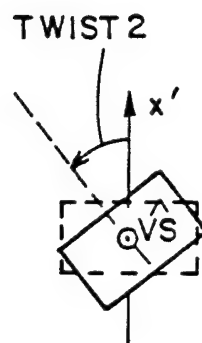
SIDE VIEW



FRONT VIEW



NO TWISTING



TWISTING

Figure 5. Definition of twist angle.

\hat{V}_I : Incident unit vector

\hat{V}_S : Unit vector along the strut axis

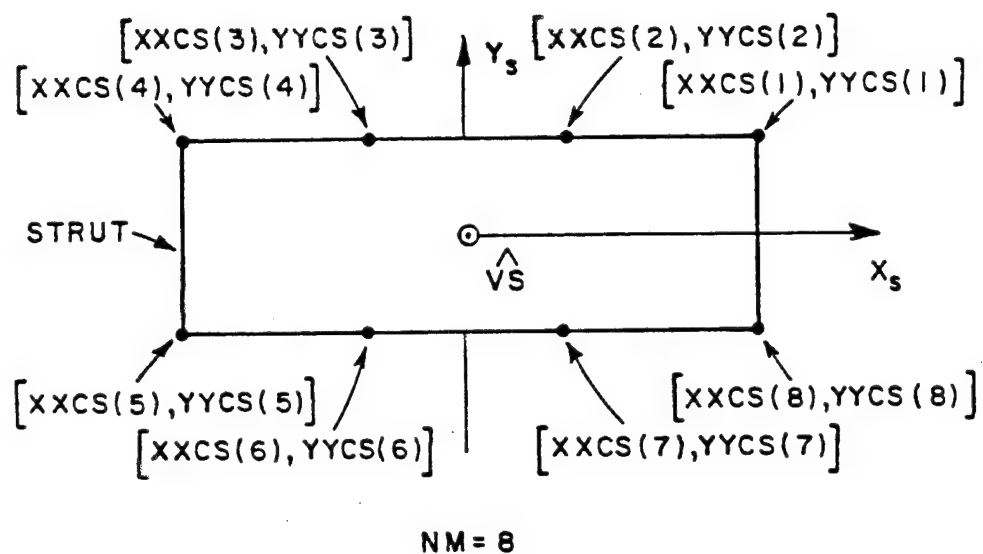
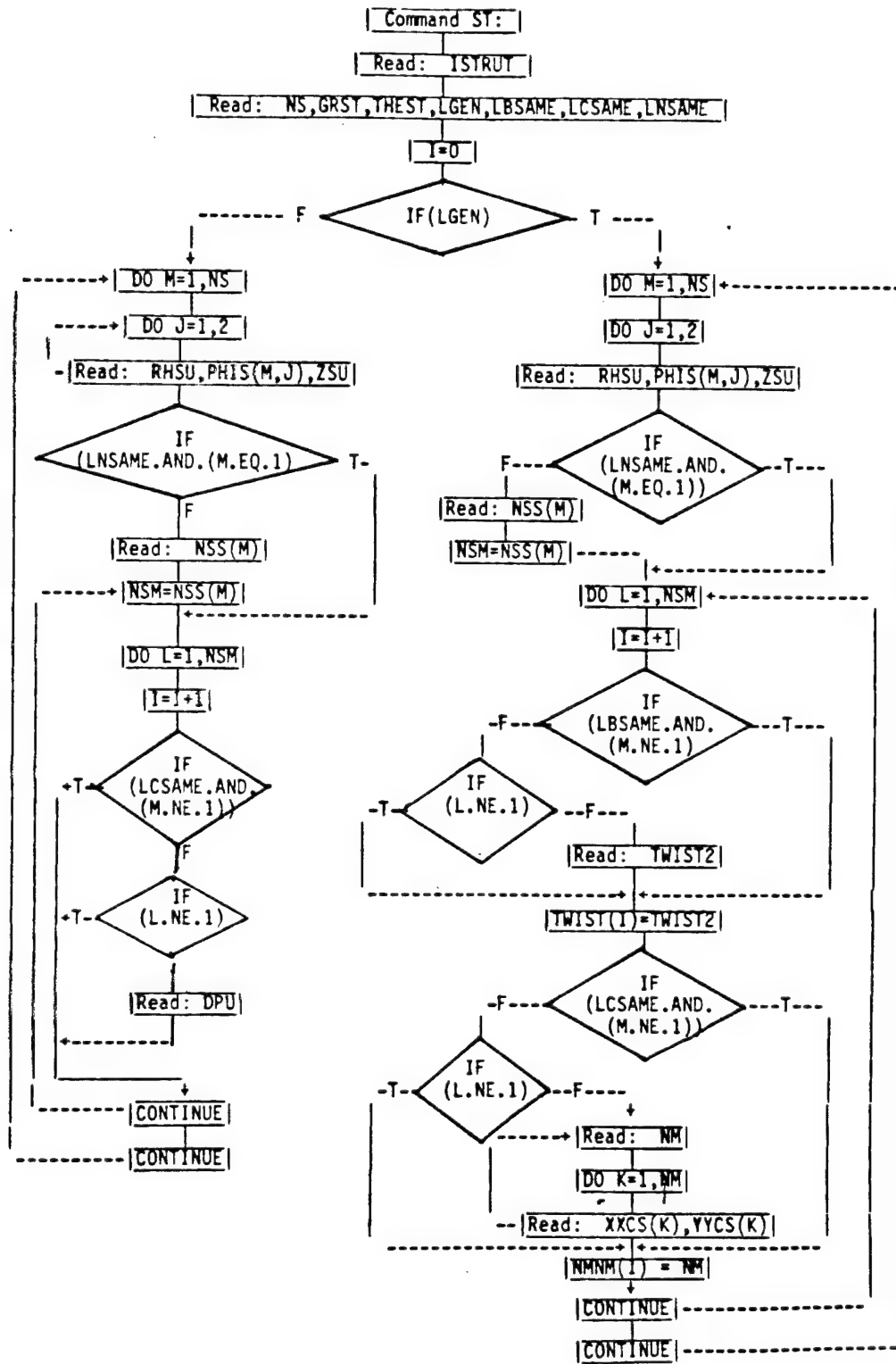


Figure 6. Local coordinate system of a strut with rectangular cross section.

BLOCK DIAGRAM FOR STRUT SCATTERING



Example 1:

This example illustrates how struts with general cross sections (LGEN=T) are input. The default antenna with one rectangular strut is used and shown in Figure 7. The cross section of the strut is 0.75" x 0.43". The feed patterns are the same as in example 2 of Appendix B and the blockage effects of the feed are also included in the calculation. The 90° cut patterns of total field and reflector/strut scattering field (ISTRUT=1) are given in Figure 8. In Figure 8(b), the null at $\theta = -68.1^\circ$ is due to the situation that the field point is right along the strut axis. The input data are given in Table 1.

TABLE 1
INPUT DATA FOR THE EXAMPLE WITH SINGLE RECTANGULAR STRUT

CM: ***** STRUT1.DAT *****
CM: EXAMPLE OF REFLECTOR STRUT SCATTERING
CM: 1 RECTANGULAR STRUT
CE: FEED BLOCKAGE
FD:

0	T				
T	0	F	1	90.	0.
2	0.	90.			F

14

0.	1.0000	0.	0.	0.
10.	0.9575	0.	0.	0.
20.	0.8419	0.	0.	0.
30.	0.6840	0.	0.	0.
40.	0.5200	0.	0.	0.
50.	0.3772	0.	0.	0.
60.	0.2664	0.	0.	0.
70.	0.1866	0.	0.	0.
80.	0.1358	0.	0.	0.
90.	0.10521	0.	0.	0.
120.	0.03588	0.	0.	0.
132.	0.05475	0.	0.	0.
160.	0.01884	0.	0.	0.
180.	0.02240	0.	0.	0.
0.	1.0000	0.	0.	0.
10.	0.9660	0.	0.	0.
20.	0.8714	0.	0.	0.
30.	0.7375	0.	0.	0.
40.	0.5900	0.	0.	0.
50.	0.4522	0.	0.	0.
60.	0.3360	0.	0.	0.
70.	0.2456	0.	0.	0.
80.	0.1813	0.	0.	0.
90.	0.13778	0.	0.	0.
120.	0.09170	0.	0.	0.
132.	0.07900	0.	0.	0.
170.	0.02114	0.	0.	0.
180.	0.02427	0.	0.	0.

FB:
1 0. 0. 8.

2.4

ST:

1	0.5	110.	T	T	T	T
10.8	90.	3.65				
0.	0.	8.				

3

0.

10

0.375	0.215
0.125	0.215
-0.125	0.215
-0.375	0.215
-0.375	0.000
-0.375	-0.215
-0.125	-0.215
0.125	-0.215
0.375	-0.215
0.375	0.000

PZ:

1

90.

-180. 180. 0.5

F

PP:

2

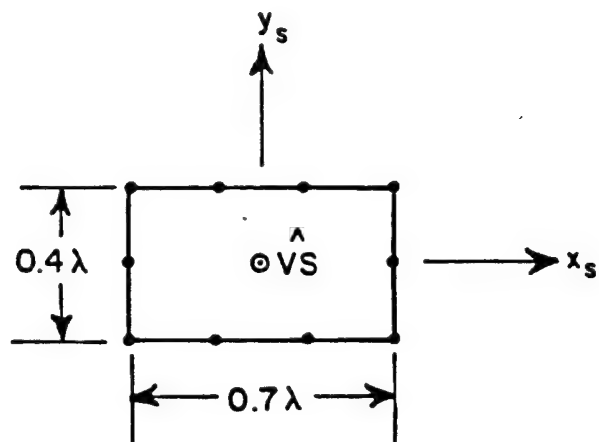
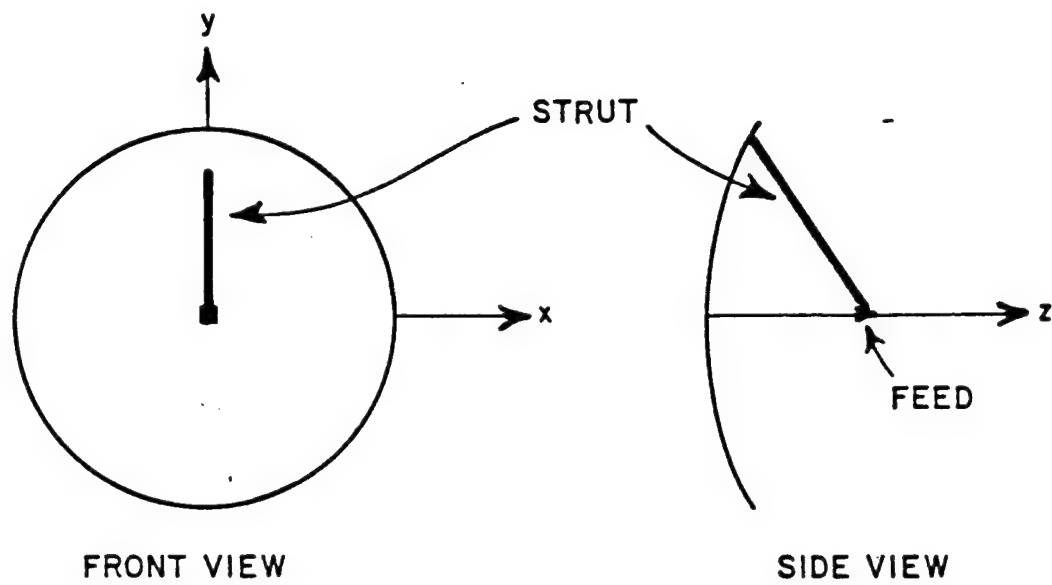
1 1

1 2

4 1

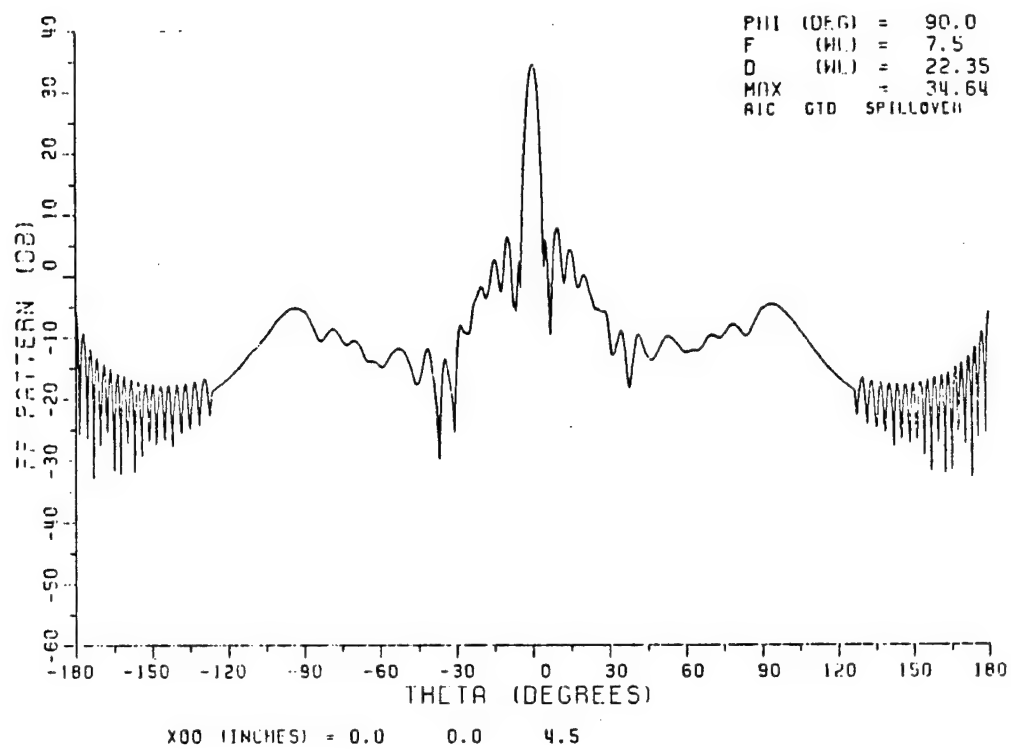
1 2

XQ:

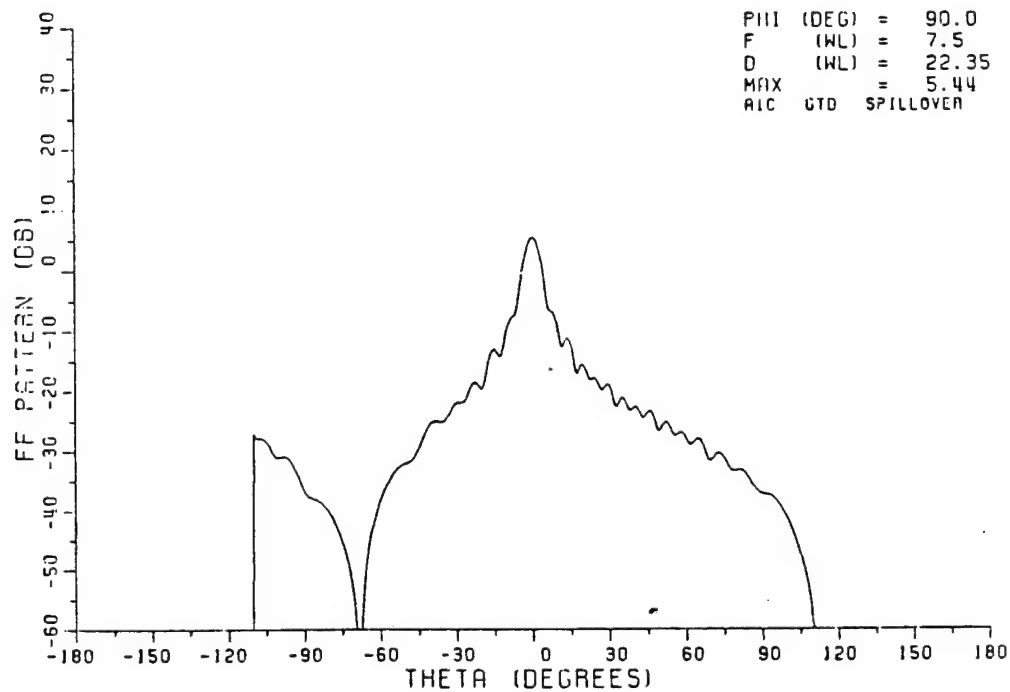


STRUT CROSS SECTION NM = 10

Figure 7. Geometry of reflector with one rectangular strut.



(a) total field



(b) strut scattering

Figure 8. Far field patterns of example 2 for PHI=90.0 degrees.

Example 2:

This example illustrates how the feed/strut scattering pattern (ISTRUT=2) of a reflector antenna can be calculated by using the ST: command. Struts with circular cross section (LGEN=F) are used in this example to model the hoop around the circumference of a 4-quadrant reflector (with a radius of 7.5 m) as shown in Figure 9. The feed is pointed toward the center of one quadrant. Consequently, the reflector rim corresponds to the single quadrant as shown in Figure 9. The surface which corresponds to the other three quadrants is open. The incident fields on the struts are from the feed directly, i.e., a feed/strut scattering case. The feed of this example is a 19 element array and the feed data are identical to the example in the AF: command. However, the increment in feed data for each cut is 1 degree in this example. The calculated patterns for the strut scattering, the reflector fields alone, and the total fields are shown in Figure 10. The input data for this example are given in Table 2.

TABLE 2
INPUT DATA FOR THE FEED/STRUT SCATTERING CALCULATION

```

CM:      ***** STRUT2.DAT *****
CM:      EXAMPLE OF FEED/STRUT SCATTERING
CM:      19 ELEMENTS ARRAY FEED
CE:
DG:
1
3  366.85  3.0  3.0  0.  22
208.791    188.003
191.766    203.741
173.558    218.094
154.281    230.975
134.052    242.304
112.997    252.011
 91.245    260.035
 68.931    266.329
 46.191    270.852
 23.167    273.577
  0.000    274.487
-23.167    273.577
-46.191    270.852
-68.931    266.329
-91.245    260.035
-112.997   252.011
-134.052   242.304
-154.281   230.975
-173.558   218.094
-191.766   203.741
-208.791   188.003
  0.000    -20.788
TO:
F  0.  0.
F  0  0  0  0
F  F  F  F  0
T  T  F  0.8
T  F  F  F  T  F  0.  0.
T  T  0.  0.
FD: FOCUSED 19 ELEMENTS ARRAY FEED
0  T
T  0  T  1  90.  0.  F
10 0. 10. 20. 30. 40. 50. 60. 70. 80. 90.
91
      0.000      12.514      90.000      -300.000      0.000
      1.000      12.476      90.000      -300.000      0.000
      2.000      12.360      90.000      -300.000      0.000
      3.000      12.166      90.000      -300.000      0.000
      4.000      11.894      90.000      -300.000      0.000
      5.000      11.541      90.000      -300.000      0.000
      6.000      11.107      90.000      -300.000      0.000
      7.000      10.590      90.000      -300.000      0.000
      8.000      9.988      90.000      -300.000      0.000
      9.000      9.299      90.000      -300.000      0.000
     10.000      8.517      90.000      -300.000      0.000
     11.000      7.640      90.000      -300.000      0.000
     12.000      6.662      90.000      -300.000      0.000
     13.000      5.579      90.000      -300.000      0.000
     14.000      4.385      90.000      -300.000      0.000
     15.000      3.071      90.000      -300.000      0.000
     16.000      1.629      90.000      -300.000      0.000
     17.000      0.049      90.000      -300.000      0.000
     18.000     -1.679      90.000      -300.000      0.000
     19.000     -3.567      90.000      -300.000      0.000

```

TABLE 2 - CONTINUED

20.000	-5.627	90.000	-300.000	0.000
21.000	-7.867	90.000	-300.000	0.000
22.000	-10.287	90.000	-300.000	0.000
23.000	-12.865	90.000	-300.000	0.000
24.000	-15.538	90.000	-300.000	0.000
25.000	-18.155	90.000	-300.000	0.000
26.000	-20.446	90.000	-300.000	0.000
27.000	-22.038	90.000	-300.000	0.000
28.000	-22.640	90.000	-300.000	0.000
29.000	-22.276	90.000	-300.000	0.000
30.000	-21.261	90.000	-300.000	0.000
31.000	-19.964	90.000	-300.000	0.000
32.000	-18.643	90.000	-300.000	0.000
33.000	-17.434	90.000	-300.000	0.000
34.000	-16.395	90.000	-300.000	0.000
35.000	-15.548	90.000	-300.000	0.000
36.000	-14.893	90.000	-300.000	0.000
37.000	-14.421	90.000	-300.000	0.000
38.000	-14.126	90.000	-300.000	0.000
39.000	-13.996	90.000	-300.000	0.000
40.000	-14.024	90.000	-300.000	0.000
41.000	-14.203	90.000	-300.000	0.000
42.000	-14.526	90.000	-300.000	0.000
43.000	-14.988	90.000	-300.000	0.000
44.000	-15.586	90.000	-300.000	0.000
45.000	-16.313	90.000	-300.000	0.000
46.000	-17.163	90.000	-300.000	0.000
47.000	-18.125	90.000	-300.000	0.000
48.000	-19.185	90.000	-300.000	0.000
49.000	-20.317	90.000	-300.000	0.000
50.000	-21.480	90.000	-300.000	0.000
51.000	-22.615	90.000	-300.000	0.000
52.000	-23.634	90.000	-300.000	0.000
53.000	-24.436	90.000	-300.000	0.000
54.000	-24.910	90.000	-300.000	0.000
55.000	-24.981	90.000	-300.000	0.000
56.000	-24.630	90.000	-300.000	0.000
57.000	-23.907	90.000	-300.000	0.000
58.000	-22.904	90.000	-300.000	0.000
59.000	-21.731	90.000	-300.000	0.000
60.000	-20.475	90.000	-300.000	0.000
61.000	-19.205	90.000	-300.000	0.000
62.000	-17.964	90.000	-300.000	0.000
63.000	-16.779	90.000	-300.000	0.000
64.000	-15.664	90.000	-300.000	0.000
65.000	-14.626	90.000	-300.000	0.000
66.000	-13.666	90.000	-300.000	0.000
67.000	-12.783	90.000	-300.000	0.000
68.000	-11.976	90.000	-300.000	0.000
69.000	-11.238	90.000	-300.000	0.000
70.000	-10.568	90.000	-300.000	0.000
71.000	-9.961	90.000	-300.000	0.000
72.000	-9.413	90.000	-300.000	0.000
73.000	-8.922	90.000	-300.000	0.000
74.000	-8.482	90.000	-300.000	0.000
75.000	-8.093	90.000	-300.000	0.000
76.000	-7.749	90.000	-300.000	0.000
77.000	-7.450	90.000	-300.000	0.000
78.000	-7.192	90.000	-300.000	0.000
79.000	-6.975	90.000	-300.000	0.000
80.000	-6.795	90.000	-300.000	0.000
81.000	-6.651	90.000	-300.000	0.000
82.000	-6.542	90.000	-300.000	0.000
83.000	-6.466	90.000	-300.000	0.000
84.000	-6.422	90.000	-300.000	0.000
85.000	-6.411	90.000	-300.000	0.000

TABLE 2 - CONTINUED

86.000	-6.429	90.000	-300.000	0.000
87.000	-6.478	90.000	-300.000	0.000
88.000	-6.557	90.000	-300.000	0.000
89.000	-6.665	90.000	-300.000	0.000
90.000	-292.618	0.000	-300.000	0.000
0.000	12.514	90.000	-71.604	-89.544
1.000	12.476	90.000	-76.165	-87.245
2.000	12.360	90.000	-69.907	-50.021
3.000	12.166	90.000	-68.169	-129.977
4.000	11.893	90.000	-67.223	-129.970
5.000	11.540	90.000	-66.675	-129.970
6.000	11.106	90.000	-66.398	-129.970
7.000	10.588	90.000	-66.295	-129.972
8.000	9.986	90.000	-66.405	-129.975
9.000	9.295	90.000	-66.646	-129.975
10.000	8.511	90.000	-67.046	-129.976
11.000	7.632	90.000	-67.579	-129.977
12.000	6.651	90.000	-68.244	-129.979
13.000	5.563	90.000	-69.046	-129.980
14.000	4.361	90.000	-69.993	-129.981
15.000	3.036	90.000	-71.082	-129.981
16.000	1.576	90.000	-72.327	-129.982
17.000	-0.032	90.000	-73.736	-129.982
18.000	-1.804	90.000	-75.325	-129.983
19.000	-3.762	90.000	-77.114	-129.983
20.000	-5.932	90.000	-79.130	-129.984
21.000	-8.352	90.000	-81.406	-129.984
22.000	-11.069	90.000	-83.991	-129.984
23.000	-14.147	90.000	-86.947	-129.985
24.000	-17.674	90.000	-90.361	-129.986
25.000	-21.768	90.000	-94.351	-129.986
26.000	-26.556	90.000	-99.043	-129.986
27.000	-32.040	90.000	-104.439	-129.987
28.000	-37.378	90.000	-109.697	-129.987
29.000	-39.553	90.000	-111.798	-129.987
30.000	-37.055	90.000	-109.235	-129.987
31.000	-33.082	90.000	-105.202	-129.987
32.000	-29.566	90.000	-101.630	-129.987
33.000	-26.798	90.000	-98.814	-129.988
34.000	-24.685	90.000	-96.659	-129.988
35.000	-23.106	90.000	-95.042	-129.988
36.000	-21.964	90.000	-93.868	-129.988
37.000	-21.193	90.000	-93.069	-129.989
38.000	-20.747	90.000	-92.600	-129.989
39.000	-20.598	90.000	-92.434	-129.989
40.000	-20.735	90.000	-92.556	-129.989
41.000	-21.158	90.000	-92.969	-129.989
42.000	-21.885	90.000	-93.690	-129.989
43.000	-22.956	90.000	-94.759	-129.989
44.000	-24.447	90.000	-96.252	-129.989
45.000	-26.506	90.000	-98.316	-129.990
46.000	-29.448	90.000	-101.266	-129.990
47.000	-34.127	90.000	-105.958	-129.990
48.000	-44.964	90.000	-116.809	-129.990
49.000	-42.040	-90.000	-113.902	50.009
50.000	-33.721	-90.000	-105.604	50.009
51.000	-29.870	-90.000	-101.776	50.009
52.000	-27.513	-90.000	-99.445	50.009
53.000	-25.952	-90.000	-97.912	50.009
54.000	-24.912	-90.000	-96.903	50.009
55.000	-24.262	-90.000	-96.285	50.009
56.000	-23.932	-90.000	-95.989	50.009
57.000	-23.887	-90.000	-95.980	50.009
58.000	-24.116	-90.000	-96.246	50.009
59.000	-24.629	-90.000	-96.799	50.008
60.000	-25.461	-90.000	-97.671	50.008

TABLE 2 - CONTINUED

61.000	-26.683	-90.000	-98.934	50.008
62.000	-28.435	-90.000	-100.729	50.008
63.000	-31.020	-90.000	-103.357	50.008
64.000	-35.244	-90.000	-107.625	50.008
65.000	-45.077	-90.000	-117.502	50.008
66.000	-43.314	90.000	-115.784	-129.992
67.000	-34.103	90.000	-106.617	-129.992
68.000	-29.655	90.000	-102.213	-129.993
69.000	-26.705	90.000	-99.307	-129.992
70.000	-24.514	90.000	-97.159	-129.993
71.000	-22.791	90.000	-95.480	-129.993
72.000	-21.388	90.000	-94.119	-129.993
73.000	-20.223	90.000	-92.995	-129.993
74.000	-19.242	90.000	-92.053	-129.993
75.000	-18.410	90.000	-91.260	-129.993
76.000	-17.700	90.000	-90.587	-129.993
77.000	-17.096	90.000	-90.018	-129.993
78.000	-16.582	90.000	-89.538	-129.993
79.000	-16.149	90.000	-89.136	-129.993
80.000	-15.787	90.000	-88.803	-129.993
81.000	-15.489	90.000	-88.531	-129.993
82.000	-15.251	90.000	-88.317	-129.994
83.000	-15.067	90.000	-88.155	-129.994
84.000	-14.934	90.000	-88.041	-129.994
85.000	-14.849	90.000	-87.972	-129.994
86.000	-14.810	90.000	-87.946	-129.994
87.000	-14.816	90.000	-87.962	-129.994
88.000	-14.864	90.000	-88.018	-129.994
89.000	-14.953	90.000	-88.112	-129.994
90.000	-300.000	0.000	-300.000	0.000
0.000	12.514	90.000	-74.179	-89.097
1.000	12.476	90.000	-83.262	-84.500
2.000	12.359	90.000	-70.625	-10.052
3.000	12.165	90.000	-66.949	-169.963
4.000	11.892	90.000	-64.777	-169.950
5.000	11.539	90.000	-63.315	-169.950
6.000	11.104	90.000	-62.314	-169.951
7.000	10.586	90.000	-61.576	-169.954
8.000	9.982	90.000	-61.175	-169.958
9.000	9.290	90.000	-60.946	-169.960
10.000	8.504	90.000	-60.940	-169.962
11.000	7.621	90.000	-61.104	-169.965
12.000	6.635	90.000	-61.429	-169.967
13.000	5.538	90.000	-61.923	-169.969
14.000	4.322	90.000	-62.594	-169.970
15.000	2.974	90.000	-63.434	-169.971
16.000	1.479	90.000	-64.459	-169.972
17.000	-0.184	90.000	-65.684	-169.974
18.000	-2.046	90.000	-67.135	-169.975
19.000	-4.148	90.000	-68.854	-169.975
20.000	-6.558	90.000	-70.904	-169.976
21.000	-9.388	90.000	-73.396	-169.977
22.000	-12.849	90.000	-76.538	-169.978
23.000	-17.415	90.000	-80.805	-169.979
24.000	-24.635	90.000	-87.740	-169.980
25.000	-55.565	-90.000	-118.401	10.020
26.000	-26.388	-90.000	-88.969	10.020
27.000	-21.732	-90.000	-84.073	10.019
28.000	-19.538	-90.000	-81.650	10.019
29.000	-18.391	-90.000	-80.286	10.018
30.000	-17.831	-90.000	-79.521	10.018
31.000	-17.648	-90.000	-79.144	10.018
32.000	-17.719	-90.000	-79.029	10.017
33.000	-17.959	-90.000	-79.093	10.017
34.000	-18.302	-90.000	-79.270	10.017
35.000	-18.693	-90.000	-79.502	10.016

TABLE 2 - CONTINUED

36.000	-19.079	-90.000	-79.738	10.016
37.000	-19.415	-90.000	-79.933	10.015
38.000	-19.665	-90.000	-80.048	10.015
39.000	-19.801	-90.000	-80.057	10.015
40.000	-19.811	-90.000	-79.946	10.015
41.000	-19.697	-90.000	-79.718	10.015
42.000	-19.475	-90.000	-79.388	10.015
43.000	-19.166	-90.000	-78.977	10.014
44.000	-18.798	-90.000	-78.514	10.014
45.000	-18.397	-90.000	-78.022	10.014
46.000	-17.987	-90.000	-77.527	10.014
47.000	-17.586	-90.000	-77.047	10.014
48.000	-17.212	-90.000	-76.599	10.013
49.000	-16.875	-90.000	-76.191	10.013
50.000	-16.582	-90.000	-75.834	10.013
51.000	-16.339	-90.000	-75.530	10.013
52.000	-16.149	-90.000	-75.285	10.012
53.000	-16.014	-90.000	-75.097	10.012
54.000	-15.933	-90.000	-74.969	10.012
55.000	-15.908	-90.000	-74.900	10.012
56.000	-15.936	-90.000	-74.887	10.012
57.000	-16.017	-90.000	-74.931	10.012
58.000	-16.148	-90.000	-75.028	10.012
59.000	-16.328	-90.000	-75.178	10.011
60.000	-16.555	-90.000	-75.378	10.011
61.000	-16.828	-90.000	-75.626	10.011
62.000	-17.144	-90.000	-75.920	10.011
63.000	-17.500	-90.000	-76.257	10.011
64.000	-17.895	-90.000	-76.636	10.011
65.000	-18.329	-90.000	-77.055	10.011
66.000	-18.796	-90.000	-77.510	10.011
67.000	-19.297	-90.000	-78.001	10.011
68.000	-19.829	-90.000	-78.524	10.010
69.000	-20.390	-90.000	-79.078	10.011
70.000	-20.977	-90.000	-79.660	10.010
71.000	-21.588	-90.000	-80.268	10.010
72.000	-22.221	-90.000	-80.898	10.010
73.000	-22.872	-90.000	-81.548	10.010
74.000	-23.539	-90.000	-82.214	10.010
75.000	-24.219	-90.000	-82.894	10.010
76.000	-24.907	-90.000	-83.584	10.010
77.000	-25.601	-90.000	-84.278	10.010
78.000	-26.293	-90.000	-84.973	10.010
79.000	-26.982	-90.000	-85.664	10.010
80.000	-27.659	-90.000	-86.343	10.010
81.000	-28.319	-90.000	-87.006	10.010
82.000	-28.955	-90.000	-87.644	10.009
83.000	-29.559	-90.000	-88.251	10.009
84.000	-30.125	-90.000	-88.819	10.009
85.000	-30.643	-90.000	-89.340	10.009
86.000	-31.108	-90.000	-89.806	10.009
87.000	-31.511	-90.000	-90.211	10.009
88.000	-31.847	-90.000	-90.548	10.009
89.000	-32.112	-90.000	-90.813	10.009
90.000	-300.000	0.000	-300.000	0.000
0.000	12.514	90.000	-76.755	-88.651
1.000	12.475	90.000	-90.359	-81.755
2.000	12.359	90.000	-71.344	29.917
3.000	12.164	90.000	-65.729	150.050
4.000	11.891	90.000	-62.331	150.070
5.000	11.538	90.000	-59.956	150.071
6.000	11.103	90.000	-58.230	150.069
7.000	10.584	90.000	-56.856	150.063
8.000	9.980	90.000	-55.944	150.058
9.000	9.286	90.000	-55.245	150.055
10.000	8.499	90.000	-54.833	150.051

TABLE 2 - CONTINUED

11.000	7.613	90.000	-54.626	150.048
12.000	6.624	90.000	-54.609	150.045
13.000	5.522	90.000	-54.791	150.042
14.000	4.298	90.000	-55.180	150.040
15.000	2.939	90.000	-55.758	150.038
16.000	1.425	90.000	-56.547	150.037
17.000	-0.267	90.000	-57.561	150.035
18.000	-2.175	90.000	-58.832	150.034
19.000	-4.353	90.000	-60.412	150.032
20.000	-6.894	90.000	-62.389	150.031
21.000	-9.961	90.000	-64.923	150.030
22.000	-13.899	90.000	-68.357	150.029
23.000	-19.662	90.000	-73.641	150.028
24.000	-32.829	90.000	-86.352	150.027
25.000	-27.346	-90.000	-80.435	-29.974
26.000	-20.458	-90.000	-73.134	-29.975
27.000	-17.416	-90.000	-69.697	-29.975
28.000	-15.703	-90.000	-67.607	-29.976
29.000	-14.675	-90.000	-66.219	-29.977
30.000	-14.062	-90.000	-65.263	-29.977
31.000	-13.726	-90.000	-64.597	-29.977
32.000	-13.578	-90.000	-64.133	-29.978
33.000	-13.560	-90.000	-63.812	-29.979
34.000	-13.628	-90.000	-63.590	-29.979
35.000	-13.750	-90.000	-63.432	-29.979
36.000	-13.899	-90.000	-63.315	-29.980
37.000	-14.057	-90.000	-63.216	-29.980
38.000	-14.207	-90.000	-63.119	-29.981
39.000	-14.341	-90.000	-63.017	-29.981
40.000	-14.454	-90.000	-62.902	-29.982
41.000	-14.545	-90.000	-62.775	-29.982
42.000	-14.616	-90.000	-62.637	-29.982
43.000	-14.673	-90.000	-62.493	-29.982
44.000	-14.724	-90.000	-62.351	-29.982
45.000	-14.775	-90.000	-62.216	-29.983
46.000	-14.836	-90.000	-62.099	-29.983
47.000	-14.914	-90.000	-62.006	-29.983
48.000	-15.017	-90.000	-61.945	-29.984
49.000	-15.150	-90.000	-61.922	-29.984
50.000	-15.322	-90.000	-61.942	-29.984
51.000	-15.536	-90.000	-62.012	-29.984
52.000	-15.797	-90.000	-62.136	-29.985
53.000	-16.111	-90.000	-62.317	-29.985
54.000	-16.479	-90.000	-62.560	-29.985
55.000	-16.907	-90.000	-62.867	-29.985
56.000	-17.399	-90.000	-63.244	-29.985
57.000	-17.959	-90.000	-63.693	-29.985
58.000	-18.591	-90.000	-64.221	-29.985
59.000	-19.303	-90.000	-64.833	-29.986
60.000	-20.101	-90.000	-65.536	-29.986
61.000	-20.995	-90.000	-66.340	-29.986
62.000	-21.998	-90.000	-67.257	-29.986
63.000	-23.127	-90.000	-68.305	-29.986
64.000	-24.406	-90.000	-69.507	-29.986
65.000	-25.871	-90.000	-70.899	-29.986
66.000	-27.576	-90.000	-72.535	-29.986
67.000	-29.609	-90.000	-74.503	-29.986
68.000	-32.129	-90.000	-76.962	-29.987
69.000	-35.467	-90.000	-80.242	-29.986
70.000	-40.517	-90.000	-85.237	-29.987
71.000	-52.100	-90.000	-96.771	-29.988
72.000	-48.064	90.000	-92.687	150.012
73.000	-40.109	90.000	-84.688	150.013
74.000	-36.314	90.000	-80.853	150.013
75.000	-33.898	90.000	-78.399	150.013
76.000	-32.184	90.000	-76.650	150.013

TABLE 2 - CONTINUED

77.000	-30.901	90.000	-75.334	150.013
78.000	-29.908	90.000	-74.313	150.013
79.000	-29.131	90.000	-73.508	150.013
80.000	-28.515	90.000	-72.869	150.013
81.000	-28.030	90.000	-72.363	150.013
82.000	-27.652	90.000	-71.965	150.012
83.000	-27.364	90.000	-71.661	150.012
84.000	-27.154	90.000	-71.436	150.012
85.000	-27.012	90.000	-71.282	150.012
86.000	-26.932	90.000	-71.192	150.012
87.000	-26.908	90.000	-71.160	150.012
88.000	-26.936	90.000	-71.184	150.012
89.000	-27.015	90.000	-71.259	150.012
90.000	-300.000	0.000	-300.000	0.000
0.000	12.513	90.000	-79.330	-88.204
1.000	12.475	90.000	-97.456	-79.010
2.000	12.359	90.000	-72.063	69.886
3.000	12.164	90.000	-64.510	110.063
4.000	11.890	90.000	-59.885	110.090
5.000	11.536	90.000	-56.597	110.091
6.000	11.101	90.000	-54.147	110.088
7.000	10.582	90.000	-52.136	110.081
8.000	9.978	90.000	-50.713	110.075
9.000	9.283	90.000	-49.542	110.070
10.000	8.497	90.000	-48.723	110.065
11.000	7.611	90.000	-48.142	110.061
12.000	6.624	90.000	-47.778	110.057
13.000	5.525	90.000	-47.640	110.053
14.000	4.307	90.000	-47.733	110.051
15.000	2.958	90.000	-48.029	110.048
16.000	1.460	90.000	-48.548	110.046
17.000	-0.205	90.000	-49.294	110.044
18.000	-2.069	90.000	-50.294	110.042
19.000	-4.173	90.000	-51.585	110.040
20.000	-6.585	90.000	-53.229	110.038
21.000	-9.418	90.000	-55.334	110.037
22.000	-12.880	90.000	-58.105	110.036
23.000	-17.447	90.000	-62.014	110.035
24.000	-24.660	90.000	-68.600	110.033
25.000	-56.231	-90.000	-99.573	-69.967
26.000	-26.457	-90.000	-69.227	-69.969
27.000	-21.796	-90.000	-64.018	-69.970
28.000	-19.603	-90.000	-61.300	-69.971
29.000	-18.457	-90.000	-59.651	-69.972
30.000	-17.900	-90.000	-58.612	-69.972
31.000	-17.720	-90.000	-57.967	-69.972
32.000	-17.794	-90.000	-57.593	-69.973
33.000	-18.037	-90.000	-57.407	-69.974
34.000	-18.384	-90.000	-57.339	-69.974
35.000	-18.778	-90.000	-57.333	-69.975
36.000	-19.167	-90.000	-57.338	-69.976
37.000	-19.507	-90.000	-57.307	-69.976
38.000	-19.760	-90.000	-57.201	-69.977
39.000	-19.899	-90.000	-56.996	-69.977
40.000	-19.913	-90.000	-56.675	-69.978
41.000	-19.803	-90.000	-56.243	-69.978
42.000	-19.584	-90.000	-55.713	-69.978
43.000	-19.280	-90.000	-55.108	-69.979
44.000	-18.917	-90.000	-54.454	-69.979
45.000	-18.520	-90.000	-53.776	-69.980
46.000	-18.115	-90.000	-53.100	-69.980
47.000	-17.719	-90.000	-52.442	-69.980
48.000	-17.350	-90.000	-51.820	-69.981
49.000	-17.017	-90.000	-51.243	-69.981
50.000	-16.730	-90.000	-50.719	-69.981
51.000	-16.491	-90.000	-50.254	-69.981

TABLE 2 - CONTINUED

52.000	-16.307	-90.000	-49.849	-69.982
53.000	-16.177	-90.000	-49.507	-69.982
54.000	-16.101	-90.000	-49.227	-69.982
55.000	-16.081	-90.000	-49.009	-69.982
56.000	-16.113	-90.000	-48.852	-69.982
57.000	-16.198	-90.000	-48.754	-69.982
58.000	-16.334	-90.000	-48.713	-69.982
59.000	-16.519	-90.000	-48.729	-69.983
60.000	-16.750	-90.000	-48.798	-69.983
61.000	-17.027	-90.000	-48.919	-69.983
62.000	-17.347	-90.000	-49.088	-69.983
63.000	-17.707	-90.000	-49.305	-69.983
64.000	-18.106	-90.000	-49.567	-69.983
65.000	-18.543	-90.000	-49.872	-69.983
66.000	-19.015	-90.000	-50.218	-69.983
67.000	-19.519	-90.000	-50.603	-69.983
68.000	-20.054	-90.000	-51.024	-69.984
69.000	-20.618	-90.000	-51.479	-69.983
70.000	-21.208	-90.000	-51.966	-69.984
71.000	-21.822	-90.000	-52.484	-69.984
72.000	-22.458	-90.000	-53.027	-69.984
73.000	-23.111	-90.000	-53.594	-69.984
74.000	-23.780	-90.000	-54.183	-69.984
75.000	-24.462	-90.000	-54.788	-69.984
76.000	-25.152	-90.000	-55.408	-69.984
77.000	-25.847	-90.000	-56.036	-69.984
78.000	-26.541	-90.000	-56.671	-69.984
79.000	-27.231	-90.000	-57.304	-69.984
80.000	-27.908	-90.000	-57.932	-69.984
81.000	-28.569	-90.000	-58.547	-69.984
82.000	-29.206	-90.000	-59.142	-69.985
83.000	-29.811	-90.000	-59.712	-69.985
84.000	-30.376	-90.000	-60.246	-69.985
85.000	-30.895	-90.000	-60.739	-69.985
86.000	-31.359	-90.000	-61.181	-69.985
87.000	-31.763	-90.000	-61.568	-69.985
88.000	-32.099	-90.000	-61.892	-69.985
89.000	-32.363	-90.000	-62.149	-69.985
90.000	-300.000	0.000	-300.000	0.000
0.000	12.513	90.000	-79.643	-88.204
1.000	12.475	90.000	-79.769	-79.057
2.000	12.359	90.000	-72.376	109.792
3.000	12.163	90.000	-64.822	109.923
4.000	11.889	90.000	-60.198	109.903
5.000	11.535	90.000	-56.909	109.857
6.000	11.100	90.000	-54.459	109.807
7.000	10.580	90.000	-52.447	109.752
8.000	9.976	90.000	-51.024	109.699
9.000	9.281	90.000	-49.852	109.646
10.000	8.496	90.000	-49.030	109.594
11.000	7.613	90.000	-48.446	109.541
12.000	6.629	90.000	-48.077	109.490
13.000	5.537	90.000	-47.930	109.438
14.000	4.332	90.000	-48.009	109.386
15.000	3.003	90.000	-48.283	109.335
16.000	1.538	90.000	-48.767	109.284
17.000	-0.074	90.000	-49.458	109.232
18.000	-1.851	90.000	-50.368	109.180
19.000	-3.813	90.000	-51.516	109.129
20.000	-5.989	90.000	-52.920	109.077
21.000	-8.414	90.000	-54.615	109.025
22.000	-11.135	90.000	-56.643	108.972
23.000	-14.216	90.000	-59.063	108.920
24.000	-17.745	90.000	-61.962	108.866
25.000	-21.838	90.000	-65.453	108.813
26.000	-26.619	90.000	-69.659	108.759

TABLE 2 - CONTINUED

27.000	-32.083	90.000	-74.573	108.705
28.000	-37.386	90.000	-79.347	108.651
29.000	-39.553	90.000	-81.007	108.596
30.000	-37.106	90.000	-78.074	108.540
31.000	-33.178	90.000	-73.678	108.485
32.000	-29.690	90.000	-69.738	108.429
33.000	-26.941	90.000	-66.555	108.372
34.000	-24.843	90.000	-64.038	108.316
35.000	-23.276	90.000	-62.068	108.258
36.000	-22.146	90.000	-60.548	108.200
37.000	-21.386	90.000	-59.413	108.142
38.000	-20.952	90.000	-58.615	108.083
39.000	-20.814	90.000	-58.128	108.024
40.000	-20.963	90.000	-57.937	107.964
41.000	-21.397	90.000	-58.044	107.904
42.000	-22.137	90.000	-58.467	107.844
43.000	-23.221	90.000	-59.245	107.783
44.000	-24.729	90.000	-60.456	107.722
45.000	-26.807	90.000	-62.247	107.660
46.000	-29.777	90.000	-64.941	107.598
47.000	-34.511	90.000	-69.407	107.537
48.000	-45.627	90.000	-80.264	107.474
49.000	-42.077	-90.000	-76.463	-72.589
50.000	-33.927	-90.000	-68.070	-72.651
51.000	-30.121	-90.000	-64.031	-72.714
52.000	-27.789	-90.000	-61.472	-72.777
53.000	-26.246	-90.000	-59.710	-72.840
54.000	-25.220	-90.000	-58.474	-72.902
55.000	-24.582	-90.000	-57.631	-72.965
56.000	-24.261	-90.000	-57.113	-73.027
57.000	-24.224	-90.000	-56.886	-73.090
58.000	-24.460	-90.000	-56.939	-73.151
59.000	-24.979	-90.000	-57.281	-73.213
60.000	-25.813	-90.000	-57.947	-73.273
61.000	-27.034	-90.000	-59.004	-73.334
62.000	-28.779	-90.000	-60.592	-73.394
63.000	-31.342	-90.000	-63.004	-73.453
64.000	-35.501	-90.000	-67.020	-73.510
65.000	-44.958	-90.000	-76.336	-73.567
66.000	-44.274	90.000	-75.521	106.377
67.000	-34.742	90.000	-65.862	106.323
68.000	-30.232	90.000	-61.231	106.269
69.000	-27.261	90.000	-58.144	106.218
70.000	-25.060	90.000	-55.834	106.167
71.000	-23.333	90.000	-54.004	106.118
72.000	-21.931	90.000	-52.502	106.071
73.000	-20.766	90.000	-51.246	106.026
74.000	-19.787	90.000	-50.180	105.983
75.000	-18.958	90.000	-49.268	105.942
76.000	-18.251	90.000	-48.486	105.903
77.000	-17.650	90.000	-47.814	105.866
78.000	-17.139	90.000	-47.238	105.832
79.000	-16.709	90.000	-46.747	105.800
80.000	-16.349	90.000	-46.333	105.770
81.000	-16.055	90.000	-45.989	105.743
82.000	-15.819	90.000	-45.708	105.719
83.000	-15.637	90.000	-45.488	105.697
84.000	-15.506	90.000	-45.323	105.678
85.000	-15.423	90.000	-45.212	105.662
86.000	-15.385	90.000	-45.150	105.649
87.000	-15.392	90.000	-45.139	105.639
88.000	-15.440	90.000	-45.174	105.632
89.000	-15.531	90.000	-45.256	105.627
90.000	-300.000	0.000	-300.000	0.000
0.000	12.513	90.000	-77.694	-88.649
1.000	12.474	90.000	-91.298	-81.895

TABLE 2 - CONTINUED

2.000	12.358	90.000	-72.283	149.637
3.000	12.162	90.000	-66.668	149.629
4.000	11.888	90.000	-63.270	149.508
5.000	11.534	90.000	-60.893	149.368
6.000	11.098	90.000	-59.167	149.224
7.000	10.578	90.000	-57.791	149.077
8.000	9.973	90.000	-56.877	148.930
9.000	9.279	90.000	-56.175	148.783
10.000	8.493	90.000	-55.759	148.637
11.000	7.611	90.000	-55.544	148.490
12.000	6.629	90.000	-55.516	148.343
13.000	5.540	90.000	-55.680	148.195
14.000	4.340	90.000	-56.040	148.047
15.000	3.020	90.000	-56.574	147.899
16.000	1.571	90.000	-57.292	147.750
17.000	-0.015	90.000	-58.194	147.600
18.000	-1.750	90.000	-59.285	147.449
19.000	-3.645	90.000	-60.576	147.298
20.000	-5.713	90.000	-62.072	147.146
21.000	-7.961	90.000	-63.779	146.993
22.000	-10.388	90.000	-65.694	146.838
23.000	-12.973	90.000	-67.791	146.683
24.000	-15.652	90.000	-70.005	146.526
25.000	-18.275	90.000	-72.185	146.368
26.000	-20.572	90.000	-74.059	146.210
27.000	-22.171	90.000	-75.255	146.050
28.000	-22.785	90.000	-75.481	145.888
29.000	-22.434	90.000	-74.760	145.725
30.000	-21.436	90.000	-73.407	145.561
31.000	-20.157	90.000	-71.786	145.396
32.000	-18.851	90.000	-70.152	145.229
33.000	-17.658	90.000	-68.643	145.061
34.000	-16.635	90.000	-67.317	144.891
35.000	-15.803	90.000	-66.193	144.720
36.000	-15.161	90.000	-65.271	144.547
37.000	-14.706	90.000	-64.544	144.374
38.000	-14.425	90.000	-64.002	144.198
39.000	-14.310	90.000	-63.637	144.022
40.000	-14.353	90.000	-63.437	143.844
41.000	-14.547	90.000	-63.397	143.665
42.000	-14.886	90.000	-63.510	143.485
43.000	-15.364	90.000	-63.771	143.303
44.000	-15.978	90.000	-64.174	143.120
45.000	-16.721	90.000	-64.715	142.936
46.000	-17.587	90.000	-65.386	142.751
47.000	-18.567	90.000	-66.177	142.566
48.000	-19.646	90.000	-67.073	142.379
49.000	-20.796	90.000	-68.048	142.192
50.000	-21.979	90.000	-69.061	142.005
51.000	-23.133	90.000	-70.052	141.817
52.000	-24.174	90.000	-70.936	141.629
53.000	-24.996	90.000	-71.606	141.441
54.000	-25.491	90.000	-71.955	141.253
55.000	-25.580	90.000	-71.902	141.066
56.000	-25.244	90.000	-71.430	140.879
57.000	-24.533	90.000	-70.588	140.692
58.000	-23.542	90.000	-69.471	140.508
59.000	-22.378	90.000	-68.186	140.324
60.000	-21.132	90.000	-66.824	140.142
61.000	-19.871	90.000	-65.451	139.961
62.000	-18.640	90.000	-64.113	139.782
63.000	-17.464	90.000	-62.835	139.606
64.000	-16.359	90.000	-61.631	139.433
65.000	-15.331	90.000	-60.508	139.263
66.000	-14.381	90.000	-59.469	139.095
67.000	-13.509	90.000	-58.510	138.932

TABLE 2 - CONTINUED

68.000	-12.711	90.000	-57.630	138.772
69.000	-11.983	90.000	-56.825	138.617
70.000	-11.322	90.000	-56.090	138.466
71.000	-10.725	90.000	-55.423	138.319
72.000	-10.187	90.000	-54.818	138.179
73.000	-9.703	90.000	-54.273	138.044
74.000	-9.272	90.000	-53.783	137.914
75.000	-8.891	90.000	-53.346	137.791
76.000	-8.554	90.000	-52.959	137.674
77.000	-8.262	90.000	-52.619	137.564
78.000	-8.011	90.000	-52.324	137.461
79.000	-7.800	90.000	-52.072	137.365
80.000	-7.625	90.000	-51.861	137.276
81.000	-7.487	90.000	-51.689	137.195
82.000	-7.382	90.000	-51.554	137.122
83.000	-7.310	90.000	-51.457	137.058
84.000	-7.270	90.000	-51.394	137.001
85.000	-7.262	90.000	-51.366	136.953
86.000	-7.283	90.000	-51.371	136.914
87.000	-7.334	90.000	-51.410	136.883
88.000	-7.414	90.000	-51.481	136.861
89.000	-7.523	90.000	-51.585	136.847
90.000	-292.626	0.000	-292.626	0.000
0.000	12.512	90.000	-75.745	-89.095
1.000	12.474	90.000	-84.827	-84.732
2.000	12.357	90.000	-72.190	-170.519
3.000	12.162	90.000	-68.514	-170.665
4.000	11.887	90.000	-66.341	-170.887
5.000	11.533	90.000	-64.878	-171.121
6.000	11.096	90.000	-63.875	-171.359
7.000	10.576	90.000	-63.135	-171.598
8.000	9.970	90.000	-62.732	-171.839
9.000	9.274	90.000	-62.500	-172.079
10.000	8.487	90.000	-62.490	-172.320
11.000	7.603	90.000	-62.649	-172.561
12.000	6.618	90.000	-62.966	-172.804
13.000	5.524	90.000	-63.449	-173.048
14.000	4.316	90.000	-64.103	-173.292
15.000	2.985	90.000	-64.917	-173.537
16.000	1.518	90.000	-65.904	-173.783
17.000	-0.096	90.000	-67.070	-174.032
18.000	-1.875	90.000	-68.428	-174.282
19.000	-3.840	90.000	-69.998	-174.533
20.000	-6.018	90.000	-71.804	-174.785
21.000	-8.446	90.000	-73.881	-175.040
22.000	-11.169	90.000	-76.272	-175.296
23.000	-14.252	90.000	-79.040	-175.554
24.000	-17.783	90.000	-82.272	-175.814
25.000	-21.875	90.000	-86.080	-176.076
26.000	-26.652	90.000	-90.587	-176.340
27.000	-32.102	90.000	-95.779	-176.606
28.000	-37.373	90.000	-100.804	-176.875
29.000	-39.517	90.000	-102.713	-177.145
30.000	-37.091	90.000	-100.065	-177.418
31.000	-33.192	90.000	-95.951	-177.693
32.000	-29.723	90.000	-92.277	-177.970
33.000	-26.987	90.000	-89.344	-178.251
34.000	-24.899	90.000	-87.068	-178.533
35.000	-23.339	90.000	-85.328	-178.818
36.000	-22.215	90.000	-84.032	-179.105
37.000	-21.461	90.000	-83.112	-179.394
38.000	-21.031	90.000	-82.523	-179.686
39.000	-20.898	90.000	-82.238	-179.979
40.000	-21.050	90.000	-82.243	179.724
41.000	-21.488	90.000	-82.541	179.426
42.000	-22.229	90.000	-83.148	179.125

TABLE 2 - CONTINUED

43.000	-23.314	90.000	-84.104	178.822
44.000	-24.819	90.000	-85.485	178.519
45.000	-26.891	90.000	-87.438	178.212
46.000	-29.845	90.000	-90.278	177.904
47.000	-34.531	90.000	-94.855	177.595
48.000	-45.337	90.000	-105.555	177.285
49.000	-42.538	-90.000	-102.656	-3.027
50.000	-34.205	-90.000	-94.226	-3.339
51.000	-30.362	-90.000	-90.291	-3.652
52.000	-28.017	-90.000	-87.856	-3.965
53.000	-26.468	-90.000	-86.222	-4.278
54.000	-25.441	-90.000	-85.114	-4.591
55.000	-24.804	-90.000	-84.399	-4.903
56.000	-24.486	-90.000	-84.006	-5.214
57.000	-24.453	-90.000	-83.900	-5.525
58.000	-24.693	-90.000	-84.072	-5.833
59.000	-25.217	-90.000	-84.530	-6.140
60.000	-26.058	-90.000	-85.308	-6.443
61.000	-27.286	-90.000	-86.477	-6.744
62.000	-29.041	-90.000	-88.175	-7.042
63.000	-31.620	-90.000	-90.698	-7.335
64.000	-35.811	-90.000	-94.838	-7.624
65.000	-45.415	-90.000	-104.390	-7.908
66.000	-44.327	90.000	-103.256	171.814
67.000	-34.927	90.000	-93.811	171.541
68.000	-30.448	90.000	-89.289	171.275
69.000	-27.491	90.000	-86.291	171.016
70.000	-25.300	90.000	-84.062	170.765
71.000	-23.581	90.000	-82.306	170.521
72.000	-22.184	90.000	-80.875	170.286
73.000	-21.025	90.000	-79.684	170.061
74.000	-20.051	90.000	-78.680	169.845
75.000	-19.225	90.000	-77.825	169.640
76.000	-18.522	90.000	-77.097	169.445
77.000	-17.925	90.000	-76.474	169.261
78.000	-17.417	90.000	-75.944	169.090
79.000	-16.989	90.000	-75.495	168.930
80.000	-16.632	90.000	-75.120	168.782
81.000	-16.340	90.000	-74.810	168.648
82.000	-16.106	90.000	-74.561	168.526
83.000	-15.926	90.000	-74.367	168.418
84.000	-15.796	90.000	-74.226	168.324
85.000	-15.714	90.000	-74.135	168.244
86.000	-15.678	90.000	-74.090	168.178
87.000	-15.685	90.000	-74.091	168.126
88.000	-15.734	90.000	-74.136	168.090
89.000	-15.825	90.000	-74.224	168.068
90.000	-300.000	0.000	-300.000	0.000
0.000	12.512	90.000	-73.796	-89.540
1.000	12.473	90.000	-78.357	-87.570
2.000	12.357	90.000	-72.098	-130.674
3.000	12.161	90.000	-70.359	-130.959
4.000	11.886	90.000	-69.413	-131.281
5.000	11.531	90.000	-68.862	-131.610
6.000	11.094	90.000	-68.583	-131.941
7.000	10.573	90.000	-68.478	-132.274
8.000	9.966	90.000	-68.586	-132.607
9.000	9.269	90.000	-68.826	-132.942
10.000	8.479	90.000	-69.224	-133.277
11.000	7.592	90.000	-69.756	-133.613
12.000	6.601	90.000	-70.421	-133.951
13.000	5.498	90.000	-71.227	-134.290
14.000	4.276	90.000	-72.182	-134.631
15.000	2.922	90.000	-73.288	-134.973
16.000	1.421	90.000	-74.560	-135.317
17.000	-0.250	90.000	-76.018	-135.664

TABLE 2 - CONTINUED

18.000	-2.118	90.000	-77.688	-136.013
19.000	-4.227	90.000	-79.613	-136.363
20.000	-6.644	90.000	-81.857	-136.716
21.000	-9.481	90.000	-84.533	-137.072
22.000	-12.947	90.000	-87.849	-137.430
23.000	-17.517	90.000	-92.275	-137.790
24.000	-24.723	90.000	-99.348	-138.154
25.000	-57.356	-90.001	-131.856	41.483
26.000	-26.592	-90.000	-100.973	41.111
27.000	-21.925	-90.000	-96.196	40.739
28.000	-19.736	-90.000	-93.902	40.363
29.000	-18.597	-90.000	-92.665	39.984
30.000	-18.049	-90.000	-92.024	39.602
31.000	-17.878	-90.000	-91.767	39.218
32.000	-17.962	-90.000	-91.767	38.830
33.000	-18.216	-90.000	-91.944	38.438
34.000	-18.574	-90.000	-92.229	38.042
35.000	-18.979	-90.000	-92.566	37.644
36.000	-19.381	-90.000	-92.904	37.242
37.000	-19.733	-90.000	-93.196	36.838
38.000	-19.998	-90.000	-93.404	36.429
39.000	-20.150	-90.000	-93.502	36.019
40.000	-20.174	-90.000	-93.478	35.604
41.000	-20.076	-90.000	-93.332	35.186
42.000	-19.867	-90.000	-93.080	34.766
43.000	-19.572	-90.000	-92.745	34.342
44.000	-19.218	-90.000	-92.353	33.917
45.000	-18.830	-90.000	-91.931	33.488
46.000	-18.433	-90.000	-91.501	33.057
47.000	-18.047	-90.000	-91.085	32.625
48.000	-17.687	-90.000	-90.696	32.190
49.000	-17.363	-90.000	-90.347	31.754
50.000	-17.084	-90.000	-90.044	31.317
51.000	-16.855	-90.000	-89.793	30.879
52.000	-16.680	-90.000	-89.597	30.441
53.000	-16.558	-90.000	-89.458	30.002
54.000	-16.492	-90.000	-89.375	29.564
55.000	-16.481	-90.000	-89.349	29.127
56.000	-16.523	-90.000	-89.377	28.692
57.000	-16.618	-90.000	-89.458	28.257
58.000	-16.763	-90.000	-89.592	27.826
59.000	-16.956	-90.000	-89.775	27.397
60.000	-17.197	-90.000	-90.007	26.972
61.000	-17.483	-90.000	-90.284	26.550
62.000	-17.812	-90.000	-90.605	26.134
63.000	-18.182	-90.000	-90.968	25.723
64.000	-18.590	-90.000	-91.371	25.319
65.000	-19.036	-90.000	-91.810	24.922
66.000	-19.516	-90.000	-92.286	24.532
67.000	-20.029	-90.000	-92.794	24.151
68.000	-20.572	-90.000	-93.334	23.778
69.000	-21.144	-90.000	-93.902	23.416
70.000	-21.742	-90.000	-94.498	23.063
71.000	-22.364	-90.000	-95.116	22.722
72.000	-23.007	-90.000	-95.757	22.394
73.000	-23.668	-90.000	-96.416	22.079
74.000	-24.344	-90.000	-97.091	21.777
75.000	-25.033	-90.000	-97.777	21.489
76.000	-25.729	-90.000	-98.473	21.217
77.000	-26.431	-90.000	-99.173	20.959
78.000	-27.131	-90.000	-99.872	20.719
79.000	-27.825	-90.000	-100.565	20.495
80.000	-28.509	-90.000	-101.248	20.288
81.000	-29.175	-90.000	-101.914	20.100
82.000	-29.816	-90.000	-102.554	19.929
83.000	-30.425	-90.000	-103.162	19.779

TABLE 2 - CONTINUED

84.000	-30.995	-90.000	-103.731	19.646
85.000	-31.517	-90.000	-104.253	19.534
86.000	-31.984	-90.000	-104.720	19.443
87.000	-32.390	-90.000	-105.125	19.370
88.000	-32.728	-90.000	-105.463	19.319
89.000	-32.993	-90.000	-105.728	19.288
90.000	-300.000	0.000	-300.000	0.000
0.000	12.511	90.000	-300.000	0.000
1.000	12.473	90.000	-300.000	0.000
2.000	12.356	90.000	-300.000	0.000
3.000	12.160	90.000	-300.000	0.000
4.000	11.885	90.000	-300.000	0.000
5.000	11.530	90.000	-300.000	0.000
6.000	11.092	90.000	-300.000	0.000
7.000	10.571	90.000	-300.000	0.000
8.000	9.962	90.000	-300.000	0.000
9.000	9.265	90.000	-300.000	0.000
10.000	8.473	90.000	-300.000	0.000
11.000	7.584	90.000	-300.000	0.000
12.000	6.590	90.000	-300.000	0.000
13.000	5.482	90.000	-300.000	0.000
14.000	4.252	90.000	-300.000	0.000
15.000	2.887	90.000	-300.000	0.000
16.000	1.367	90.000	-300.000	0.000
17.000	-0.333	90.000	-300.000	0.000
18.000	-2.247	90.000	-300.000	0.000
19.000	-4.433	90.000	-300.000	0.000
20.000	-6.982	90.000	-300.000	0.000
21.000	-10.056	90.000	-300.000	0.000
22.000	-14.000	90.000	-300.000	0.000
23.000	-19.763	90.000	-300.000	0.000
24.000	-32.870	90.000	-300.000	0.000
25.000	-27.536	-90.000	-300.000	0.000
26.000	-20.633	-90.000	-300.000	0.000
27.000	-17.594	-90.000	-300.000	0.000
28.000	-15.891	-90.000	-300.000	0.000
29.000	-14.873	-90.000	-300.000	0.000
30.000	-14.274	-90.000	-300.000	0.000
31.000	-13.950	-90.000	-300.000	0.000
32.000	-13.815	-90.000	-300.000	0.000
33.000	-13.810	-90.000	-300.000	0.000
34.000	-13.893	-90.000	-300.000	0.000
35.000	-14.029	-90.000	-300.000	0.000
36.000	-14.193	-90.000	-300.000	0.000
37.000	-14.367	-90.000	-300.000	0.000
38.000	-14.532	-90.000	-300.000	0.000
39.000	-14.682	-90.000	-300.000	0.000
40.000	-14.810	-90.000	-300.000	0.000
41.000	-14.917	-90.000	-300.000	0.000
42.000	-15.003	-90.000	-300.000	0.000
43.000	-15.076	-90.000	-300.000	0.000
44.000	-15.143	-90.000	-300.000	0.000
45.000	-15.210	-90.000	-300.000	0.000
46.000	-15.286	-90.000	-300.000	0.000
47.000	-15.380	-90.000	-300.000	0.000
48.000	-15.498	-90.000	-300.000	0.000
49.000	-15.647	-90.000	-300.000	0.000
50.000	-15.835	-90.000	-300.000	0.000
51.000	-16.064	-90.000	-300.000	0.000
52.000	-16.342	-90.000	-300.000	0.000
53.000	-16.670	-90.000	-300.000	0.000
54.000	-17.055	-90.000	-300.000	0.000
55.000	-17.499	-90.000	-300.000	0.000
56.000	-18.007	-90.000	-300.000	0.000
57.000	-18.582	-90.000	-300.000	0.000
58.000	-19.230	-90.000	-300.000	0.000

TABLE 2 - CONTINUED

59.000	-19.958	-90.000	-300.000	0.000
60.000	-20.772	-90.000	-300.000	0.000
61.000	-21.682	-90.000	-300.000	0.000
62.000	-22.702	-90.000	-300.000	0.000
63.000	-23.848	-90.000	-300.000	0.000
64.000	-25.146	-90.000	-300.000	0.000
65.000	-26.631	-90.000	-300.000	0.000
66.000	-28.357	-90.000	-300.000	0.000
67.000	-30.416	-90.000	-300.000	0.000
68.000	-32.969	-90.000	-300.000	0.000
69.000	-36.357	-90.000	-300.000	0.000
70.000	-41.515	-90.000	-300.000	0.000
71.000	-53.753	-90.000	-300.000	0.000
72.000	-48.364	90.000	-300.000	0.000
73.000	-40.717	90.000	-300.000	0.000
74.000	-37.003	90.000	-300.000	0.000
75.000	-34.629	90.000	-300.000	0.000
76.000	-32.941	90.000	-300.000	0.000
77.000	-31.677	90.000	-300.000	0.000
78.000	-30.701	90.000	-300.000	0.000
79.000	-29.934	90.000	-300.000	0.000
80.000	-29.330	90.000	-300.000	0.000
81.000	-28.854	90.000	-300.000	0.000
82.000	-28.484	90.000	-300.000	0.000
83.000	-28.202	90.000	-300.000	0.000
84.000	-27.998	90.000	-300.000	0.000
85.000	-27.861	90.000	-300.000	0.000
86.000	-27.784	90.000	-300.000	0.000
87.000	-27.763	90.000	-300.000	0.000
88.000	-27.794	90.000	-300.000	0.000
89.000	-27.874	90.000	-300.000	0.000
90.000	-300.000	0.000	-300.000	0.000

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20.6 0.

ST: FEED/STRUT SCATTERING

2

24	3.0	110. F	T	T	T
280.960		42.001			47.020
277.467		57.853			47.020

4

2.50

277.467	57.853	47.020
275.248	73.880	47.020
275.248	73.880	47.020
274.487	90.000	47.020
274.487	90.000	47.020
275.248	106.120	47.020
275.248	106.120	47.020
277.467	122.147	47.020
277.467	122.147	47.020
280.960	137.999	47.020
280.960	137.999	47.020
285.449	153.616	47.020
285.449	153.616	47.020
290.589	168.962	47.020
290.589	168.962	47.020
296.006	184.027	47.020
296.006	184.027	47.020
301.325	198.821	47.020
301.325	198.821	47.020
306.199	213.371	47.020
306.199	213.371	47.020
310.323	227.715	47.020
310.323	227.715	47.020

TABLE 2 - CONTINUED

313.450	241.900	47.020
313.450	241.900	47.020
315.401	255.977	47.020
315.401	255.977	47.020
316.063	270.000	47.020
316.063	270.000	47.020
315.401	284.023	47.020
315.401	284.023	47.020
313.450	298.100	47.020
313.450	298.100	47.020
310.323	312.285	47.020
310.323	312.285	47.020
306.199	326.629	47.020
306.199	326.629	47.020
301.325	341.179	47.020
301.325	341.179	47.020
296.006	355.973	47.020
296.006	355.973	47.020
290.589	11.038	47.020
290.589	11.038	47.020
285.449	26.384	47.020
285.449	26.384	47.020
280.960	42.001	47.020

PZ:

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-30. 30. 0.1

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FP:

3

1 1

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XQ:

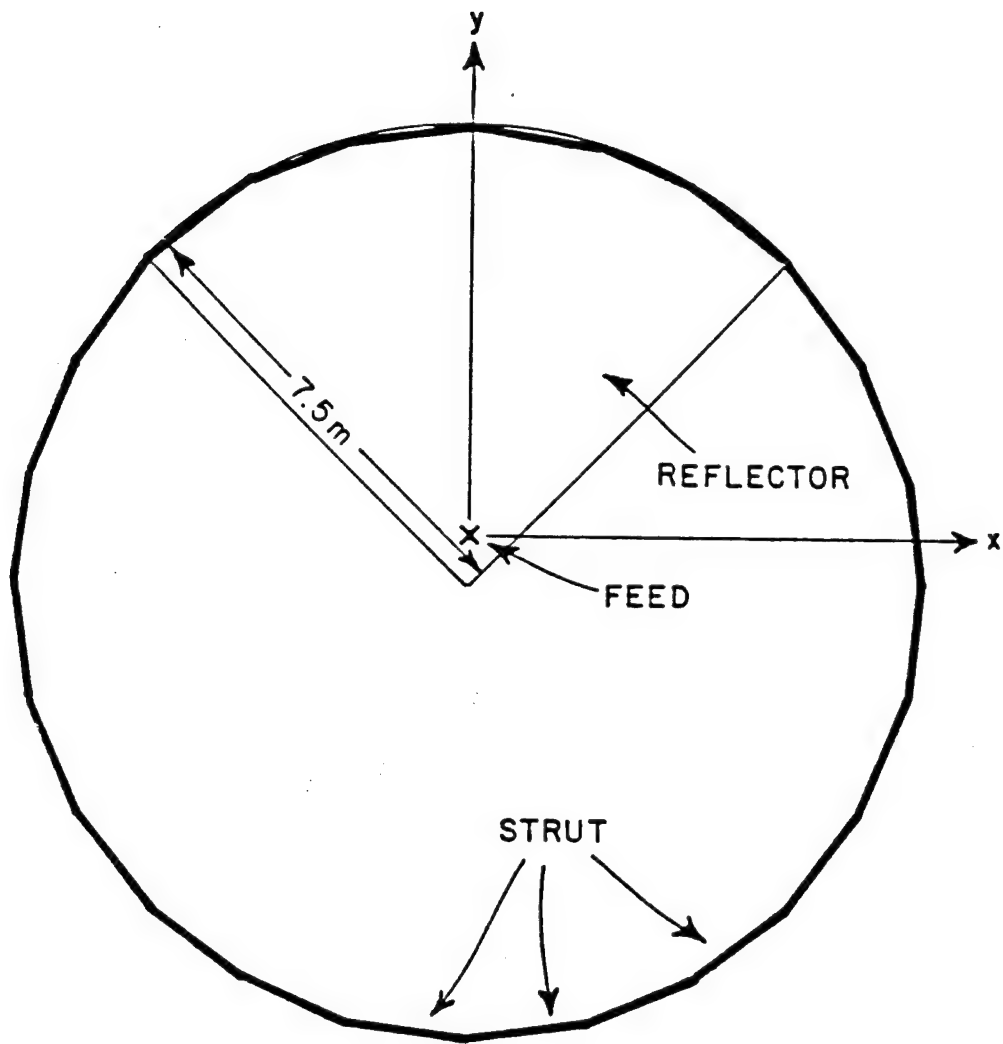
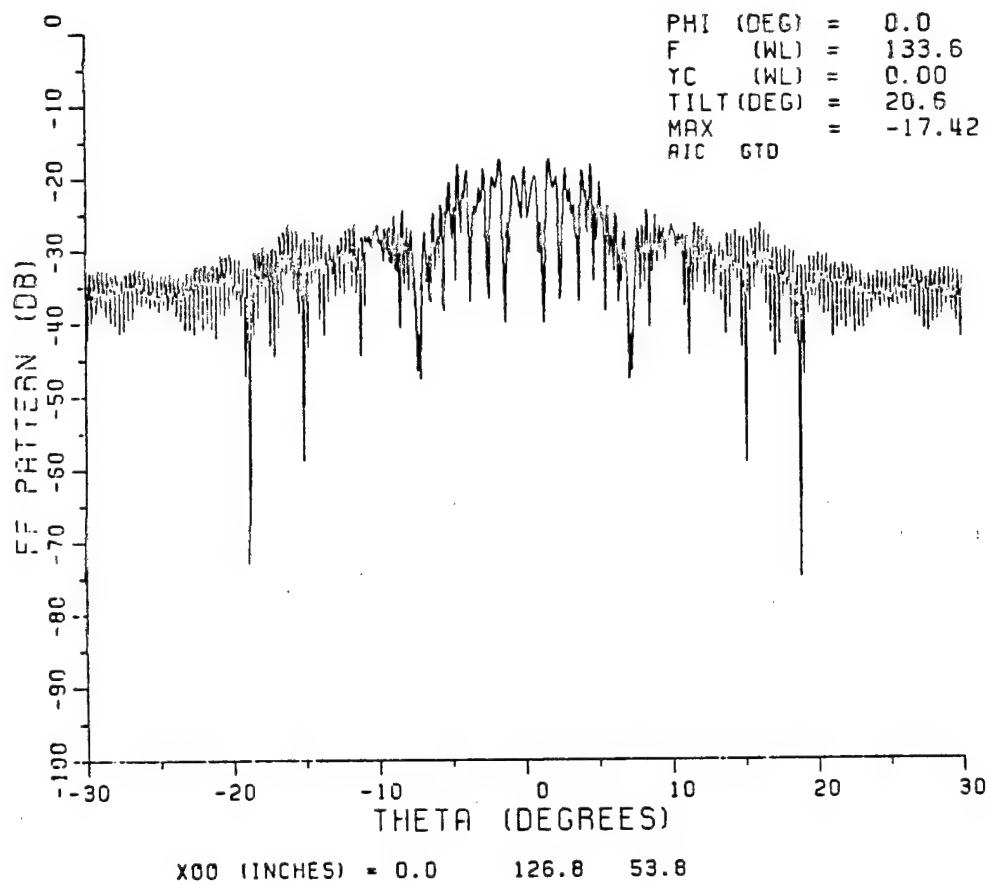
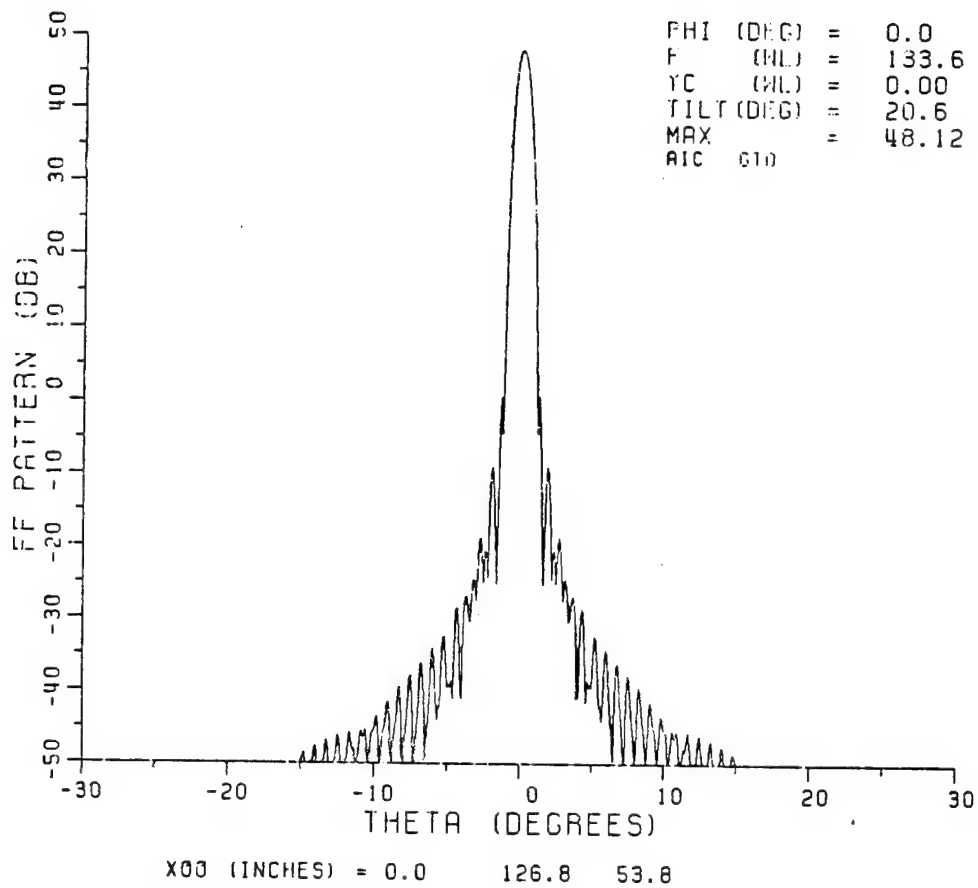


Figure 9. Geometry of a quadrant reflector with 24 struts.



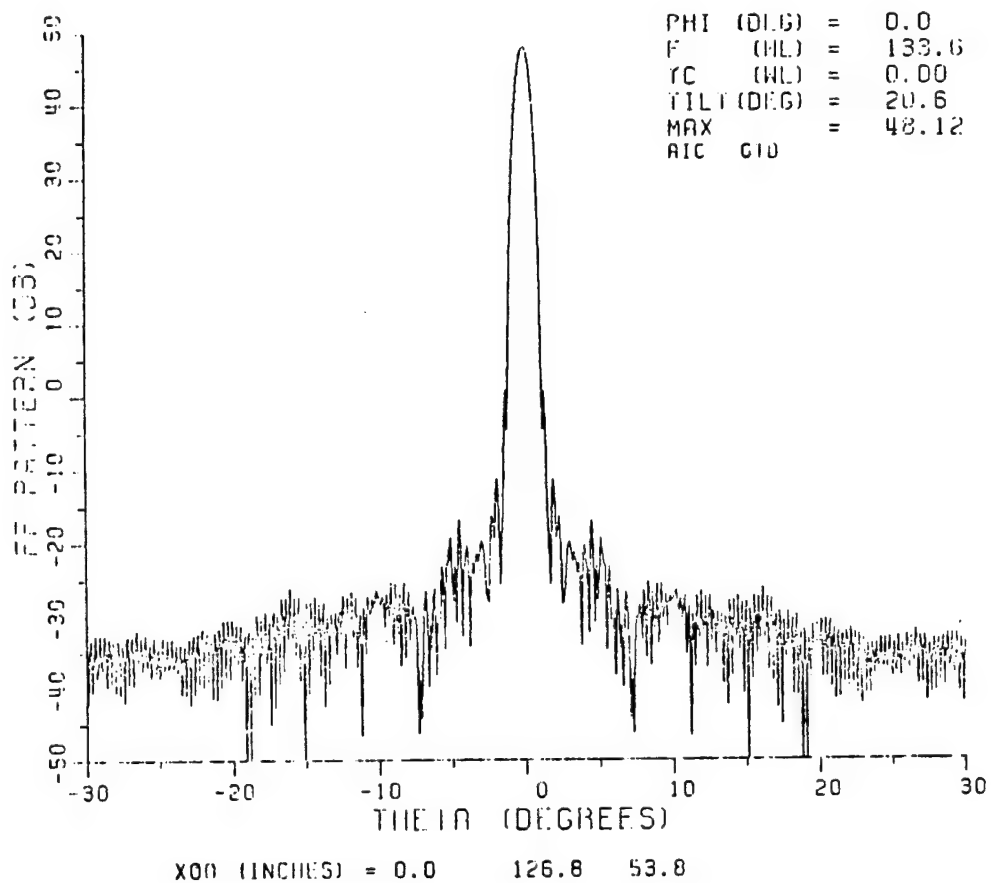
(a) feed/strut scattering fields

Figure 10. H-plane patterns of example 3.



(b) reflector fields only

Figure 10. Continued.



(c) total fields

Figure 10. Continued.

Command SP: SURFACE PERTURBATION

This command enables the user to specify a periodic surface perturbation of the reflector surface. The perturbation is specified as the displacement from the ideal surface along the surface normal. Two basic ways are used to specify the surface geometry. The first way, specified by NSURF=1, consists of a series summation; the other way, specified by NSURF=2, subdivides the surface into sub sections. This command also provides for a repetitive surface in which the reflector surface perturbation repeats over NPHS periods.

1. Read: NPHS, NSURF

- a) NPHS: This is an integer variable which specifies the number of repetitive surface sections.
- b) NSURF: This is an integer variable which specifies whether the series form or the subsectional form is used.

NSURF=1: series form
NSURF=2: subsectional form

An example of NPHS=6 and NSURF=1 is shown in Figure 1.

THE FOLLOWING 3 READ STATEMENTS ARE USED FOR NSURF=1 (SERIES FORM) ONLY.

2. Read: NSFP, NSFR

- a) NSFP: This is an integer variable which specifies the model to be used in the circumferential ϕ direction as follows:

NSFP=0: DPHSF=1 for no perturbations in the PHI-direction.

NSFP=1: DPHSF= $\cos(\pi \cdot DPQ)$ for corrugations.

NSFP=2: DPHSF= $\cos(\frac{\pi}{2} \cdot DPQ)$ for pillowing with cusps.

NSFP=3: DPHSF= $1-(DPQ)^2$ for pillowing with cusps.

- b) NSFR: This is an integer variable which specifies the model to be used in the RHO-direction as follows:

NSFR=1: DRS=DRS1 + DRS2.

NSFR=2: DRS=|DRS1| + |DRS2|.

NSFR=3: DRS=RR*(DRS1 + DRS2).

where

$$DRS1 = \sum_{1}^{NTERM} ASF(N) \cdot \sin(NSF(N) \cdot \pi \cdot RR)$$

$$DRS2 = \sum_{1}^{NTERM} BSF(N) \cdot \cos(NSF(N) \cdot \pi \cdot RR)$$

and $RR = RHO / RHOMAX$ is the normalized radius.

3. Read: NTERM

- a) NTERM: This is an integer variable which specifies the number of terms for surface perturbation used for the RHO-direction.

4. Read: ASF(N), BSF(N), NSF(N)

This read statement is executed NTERM times.

- a) ASF(N): This is a dimensional real variable which specifies the magnitude of the Nth sine term.
- b) BSF(N): This is a dimensional real variable which specifies the magnitude of the Nth cosine term.
- c) NSF(N): This is an integer variable which specifies the period of the Nth term for surface perturbation.

THE FOLLOWING READ STATEMENTS ARE USED FOR NSURF=2 (SUBSECTIONAL FORM) ONLY.

5. Read: NMRAD, LSAME

- a) NMRAD: This is an integer variable which specifies the number of subsections along the RHO-direction.
- b) LSAME: This logical variable specifies whether the types of the surface perturbation in every subsection are the same or not.

6. Read: RAD(I), I=1, NMRAD + 1

- a) RAD(I): This dimensioned variable specifies the end points for the RHO-direction of each sub section.

Note that the variable is normalized such that RAD(1)=0, and $0 < \text{RAD}(I) < 1$.

THE FOLLOWING 2 READ STATEMENTS (7 AND 8) ARE USED FOR LSAME = TRUE ONLY.

7. Read: NSFP3, NSFR3

- a) NSFP3: This is an integer variable which specifies the type of surface perturbation along the PHI-direction.

NSFP3 = 0: smooth surface in the PHI-direction

NSFP3 = 1: $\sin(\pi \cdot \text{PHIB})$, pillowed type

NSFP3 = 2: $\sin^2(\pi \cdot \text{PHIB})$, corrugated type

In Which PHIB is the normalized PHI-direction angle in each cell. (see Figure 2)

- b) NSFR3: This is an integer variable which specifies the type of surface perturbation along the RHO-direction.

NSFR3=0: constant, step type

NSFR3=1: $\sin(\pi \cdot \text{RRB})$, pillowed type

NSFR3=2: $\sin^2(\pi \cdot \text{RRB})$, corrugated type

In which RRB is the normalized RHO-direction distance in each cell.

8. Read: NMRHO(I), NMPHI(I), (ASF2(I,NJ), NJ=1,NMPHI(I))

This statement is executed NMRAD times.

- a) NMRHO(I): This dimensioned variable specifies the number of divisions along the RHO-direction in each subsection.

- b) NMPHI(I): This dimensioned variable specifies the number of divisions along the PHI-direction in each subsection. In Figure 2, an example of the subsectional form of a surface with NPHS=12 is given.

- c) ASF2(I,NJ): This dimensioned variable specifies the magnitude (peak) of the surface perturbation in the cell (see Figure 2) specified by the NJth PHI-division in subsection I. It is assumed that the amplitude of surface perturbation is identical for each cell along RHO-direction but may be different for each PHI-division in the same subsection.

THE FOLLOWING READ STATEMENTS ARE USED FOR LSAME = FALSE ONLY AND ARE EXECUTED NMRAD TIMES. (I=1,NMRAD)

9. Read: NMRHO((I),NMPHI(I))

The definition of these two dimensioned variables are the same as in read statement 8.

10. Read: NSFP2(I,NJ),NSFR2(I,NJ),ASF2(I,NJ)

This statement is executed NMPHI(I) times (NJ=1,NMPHI(I))

- a) NSFP2(I,NJ): This dimensioned integer variable specifies the type of surface perturbation along PHI-direction in the cell specified by NJth PHI-division in the Ith subsection.

NSFP2(I,NJ)=0: smooth surface in the PHI-direction

NSFP2(I,NJ)=1: $\sin(\pi \cdot \text{PHIB})$, pillowed type

NSFP2(I,NJ)=2: $\sin^2(\pi \cdot \text{PHIB})$, corrugated type

- b) NSFR2(I,NJ): This dimensioned integer variable specifies the type of surface perturbation along RHO direction in the cell specified by the NJth PHI-division in Ith subsection.

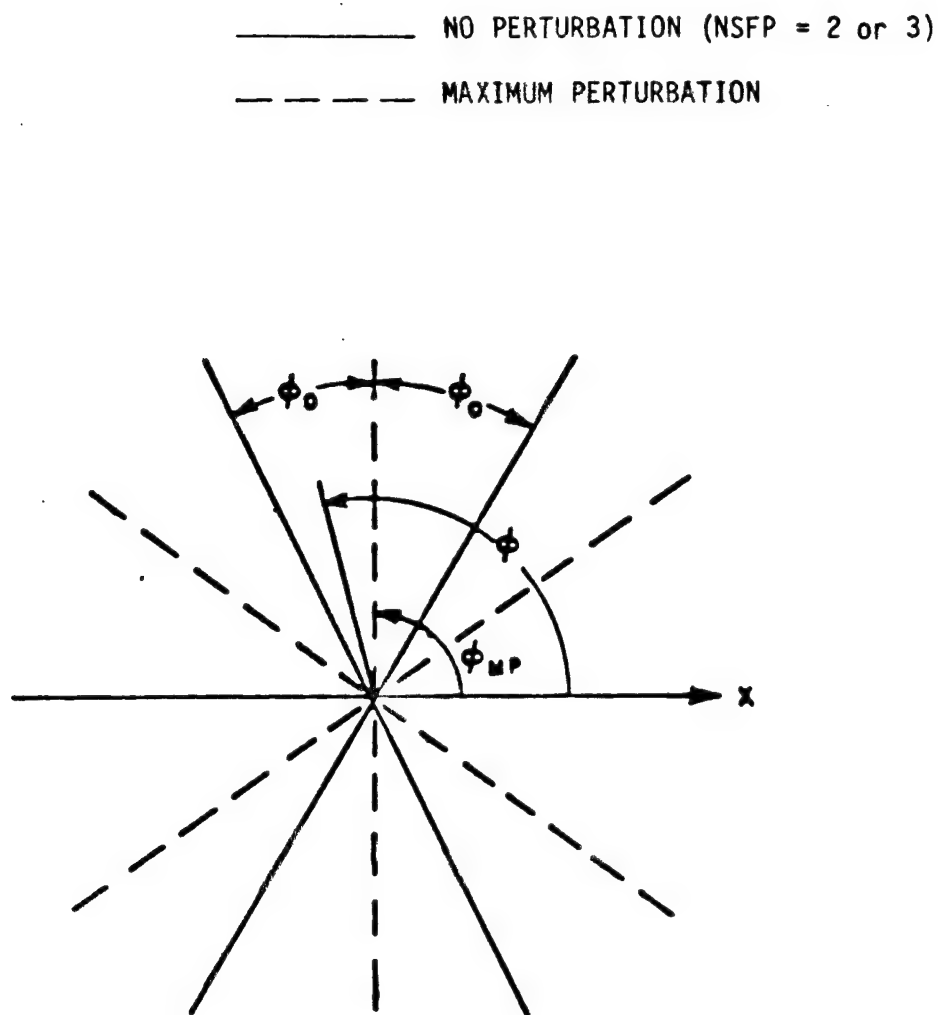
NSFR2(I,NJ)=0: constant, step type

NSFR2(I,NJ)=1: $\sin(\pi \cdot \text{RRB})$, pillowed type

NSFR2(I,NJ)=2: $\sin^2(\pi \cdot \text{RRB})$, corrugated type

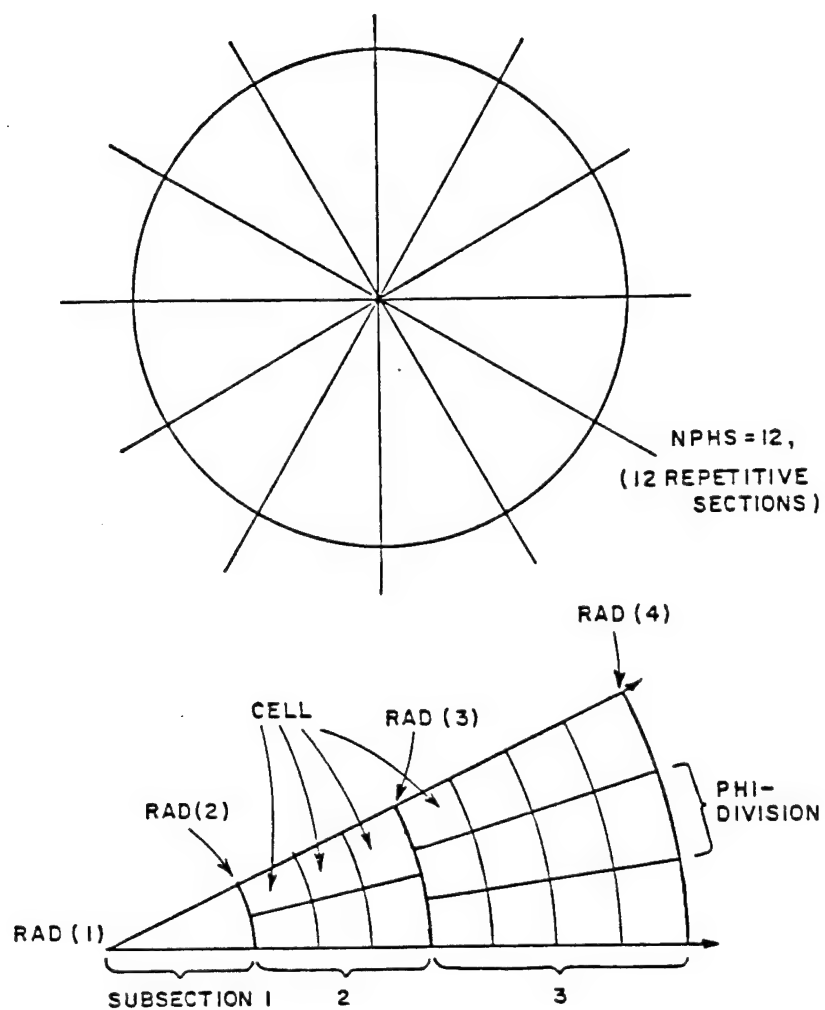
- c) ASF2(I,NJ): Same as in read statement 8. In the LSAME=FALSE case, the type and amplitude of surface perturbation of the cells along RHO-direction in each subsection are assumed to be identical.

Note: In this command, the magnitude of the surface perturbation is input in the unit which is specified in the DG: Command.



$$-1 < DPQ = \frac{\phi - \phi_{MP}}{\phi_0} < 1$$

Figure 1. Repetitive surface sections (NPHS=6 shown).



NMRAD = 3

RAD(1) = 0

NMRHO(1) = 1

NMPHI(1) = 1

RAD(2) = 0.025

NMRHO(2) = 3

NMPHI(2) = 2

RAD(3) = 0.55

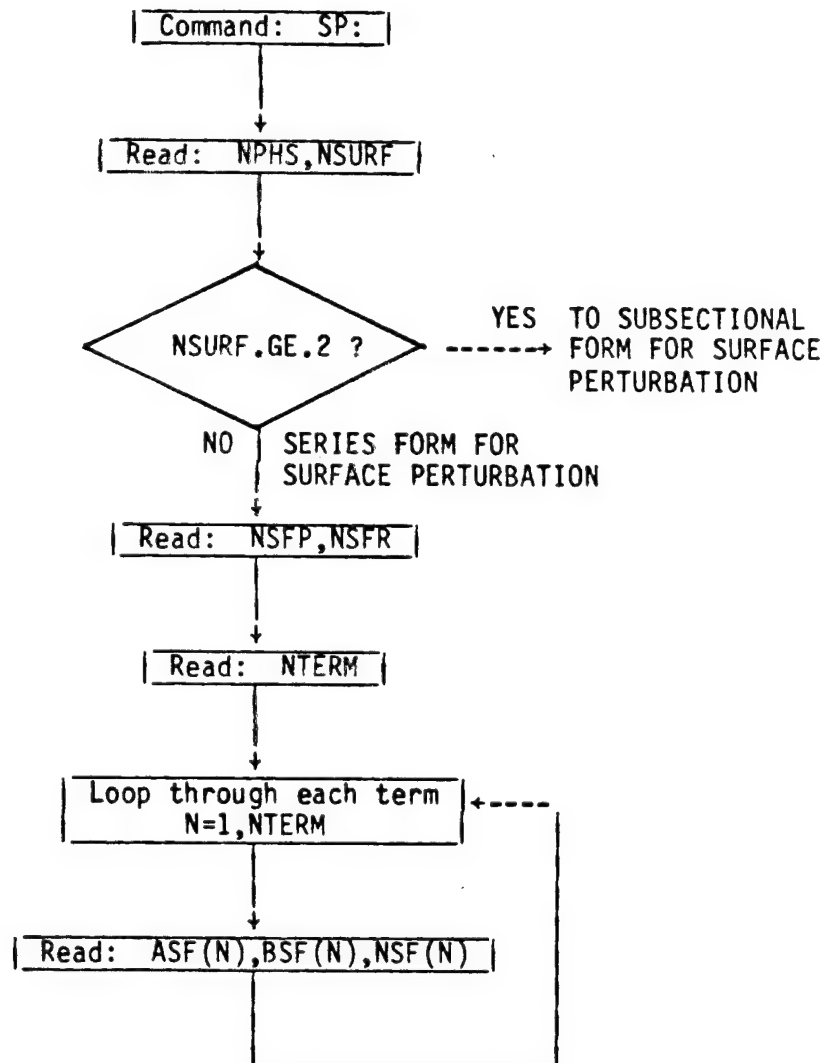
NMRHO(3) = 4

NMPHI(3) = 3

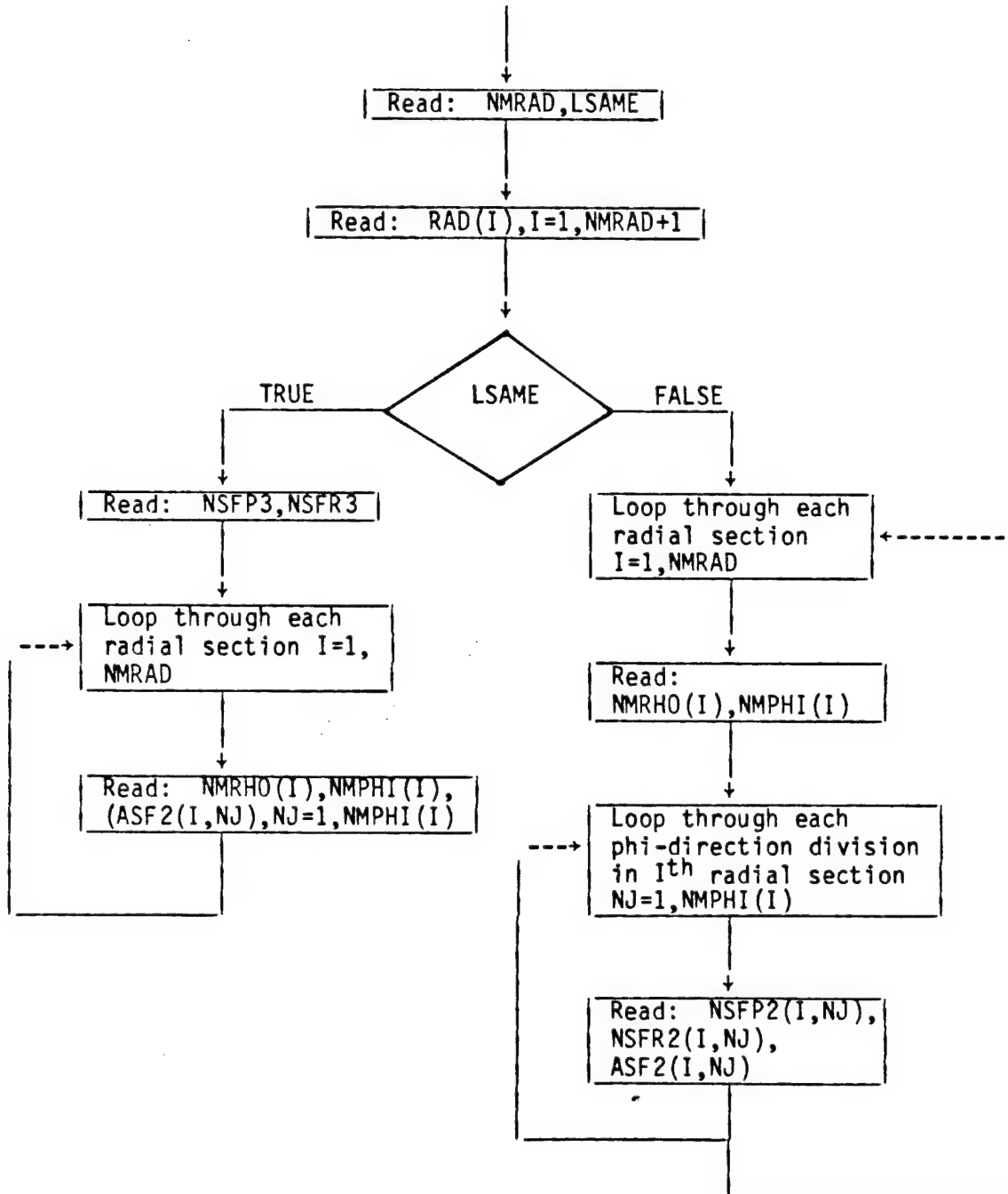
RAD(4) = 1.0

Figure 2. Example of the subsectional form of a surface.

FLOW DIAGRAM



FLOW DIAGRAM (CONTINUED)
SUBSECTIONAL FORM FOR SURFACE PERTURBATION



EXAMPLE 1:

This example demonstrates how the SP: Command is used to calculate the radiation pattern of a PI-shaped reflector. The geometry of the reflector is given in Figure 3a. In this example, the surface perturbation is the case of the subsectional form (NSURF=2) and the pillowed type (NSFR3=NSFP3=1). The input data are given in Table 1. The calculated principal plane patterns are given in Figure 4.

TABLE 1
INPUT DATA FOR CALCULATING PATTERNS OF THE PI-SHAPED REFLECTOR

```

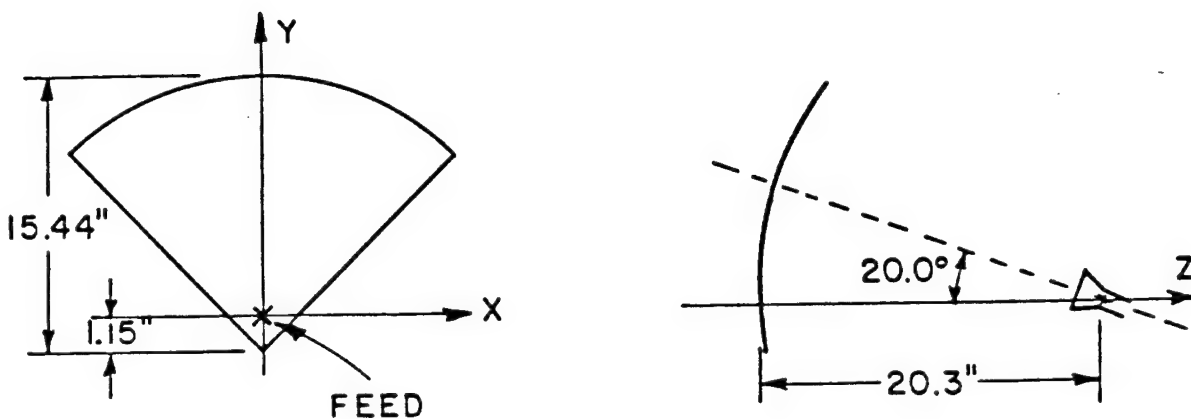
CM:      ***** SP35.DAT *****
CM:      EXAMPLE OF SURFACE PERTURBATION
CM:      SUBSECTIONAL FORM PERTURBATION
CM:      NSFP3=1, NSFR3=1 FOR
CE:      SIN(PI*X) MODEL
DG:
1
3  20.3  0.11  0.11  0.  20
10.66   9.51
9.19   10.95
8.20   11.71
7.15   12.38
6.04   12.95
4.89   13.43
3.70   13.80
2.48   14.07
1.25   14.24
0.00   14.29
-1.25  14.24
-2.48  14.07
-3.70  13.80
-4.89  13.43
-6.04  12.95
-7.15  12.38
-8.20  11.71
-9.19  10.95
-10.66 9.51
0.00  -1.15
TO: AIC ONLY
F  90.  1.
F  32  32  1  48
F  F  F  F  0
T  T  F  0.8
T  F  F  F  F  0.  0.
F  F  0.  0.
FD: NHORN=2 AND LSI=TRUE
2  T
T
11.4  1.3  11.4  1.3  0.  90.  F
FQ:
1  35.
AF:
1
0.  0.  20.3
0.  0.  0.
1.  0.
90. 20. 90.
SP:
48  2
4  T
0. 0.173 0.383 0.602 1.
1  1
1  1  0.
7  1  0.067
7  2  0.034  0.034
13 3  0.0417  0.0417  0.0417

```

```

PZ:
2
0. -90.
-90. 90.  0.5
F
PP:
1
1  1
1  2
XQ:

```



FREQUENCY = 35.0 GHz

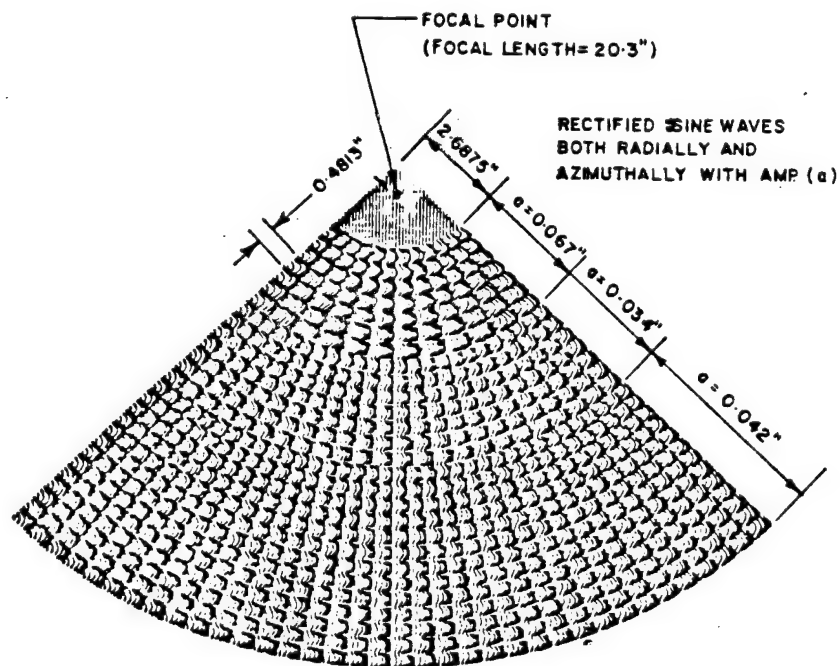
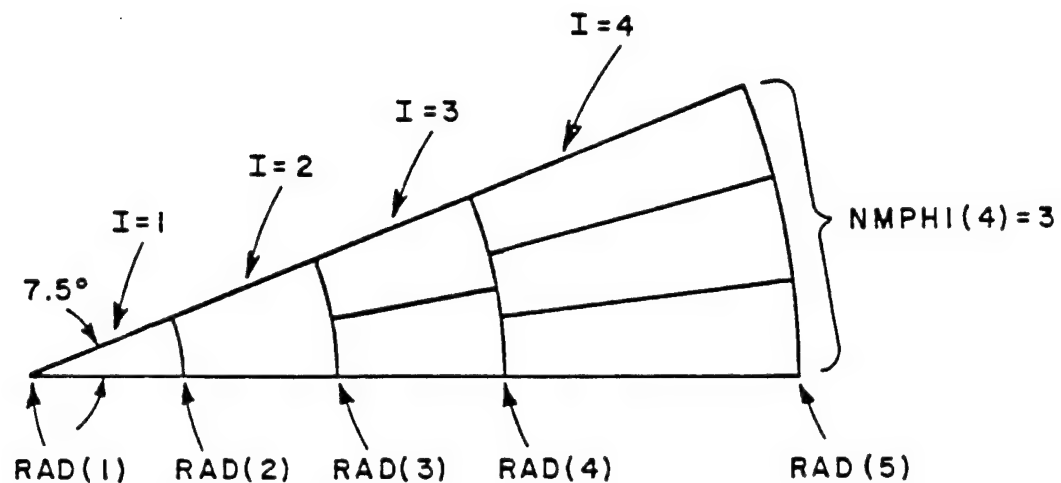


Figure 3a. Geometry of a PI-shaped reflector with pillowed surface.



NPHS =48:

NMRAD = 4

RAD(1)=0., RAD(2)=0.173, RAD(3)=0.383, RAD(4)=0.602, RAD(5)=1.0

I	1	2	3	4
NMPHI(I)	1	1	2	3
NMRHO(I)	1	7	7	13

Figure 3b. One of the repetitive sections for the reflector of Figure 3a.

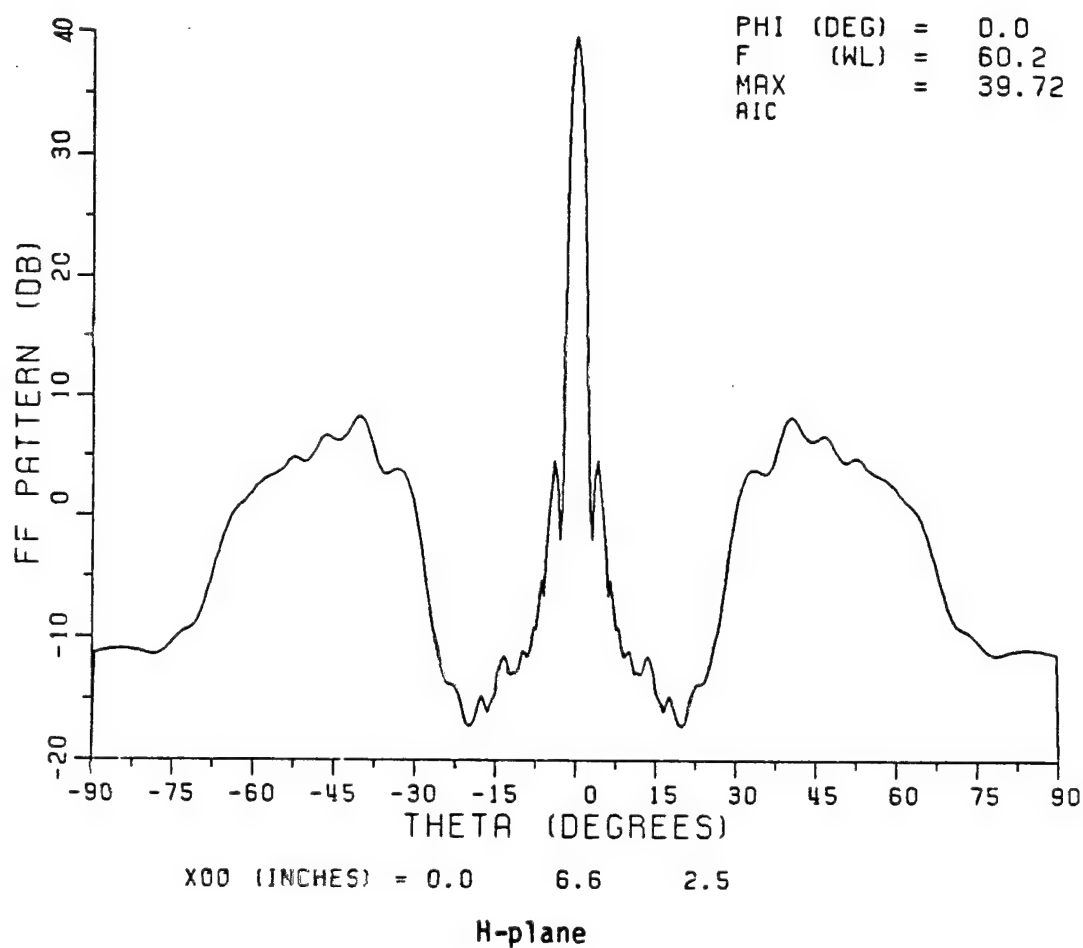
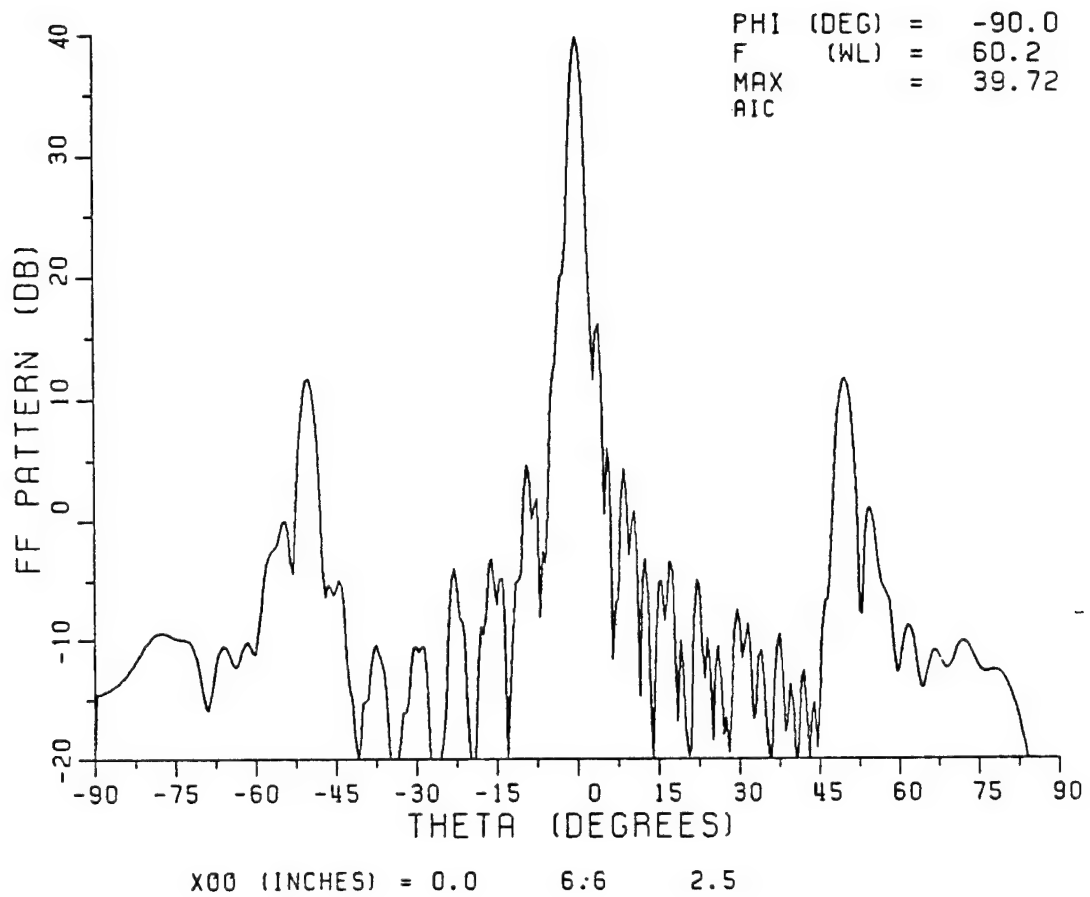


Figure 4. Radiation patterns of a pi-shaped reflector with the subsectional form (NSURF=2) and the pillowed type (NSFR3=NSFP3=1) surface perturbation.



E-plane

Figure 4. Continued.

Command SD: NONPERIODIC SURFACE DISTORTION

This command enables the user to specify the nonperiodic surface distortion of the reflector surface. The distortion is specified as the displacement along the normal from the ideal surface. It provides a capability to input the amplitude and the location of distortion. More than one location of distortion can be input. The type of distortion can be chosen from four functions for each input distortion point. The effective range of this distortion can also be specified. A system of equations is then solved to obtain the required amplitude corresponding to each distortion function.

1. Read: NPSD

- a) NPSD: This integer variable specifies the number of distortion regions on the reflector surface.

2. Read: RHOSD(NSD),PHISD(NSD),PV(NSD),RRAN(NSD),NTYPSD(NSD).

This statement is executed NPSD times. All inputs are in units.

- a) RHOSD(NSD): This variable specifies the RHO-coordinate of the center of the NSDth distortion region.
- b) PHISD(NSD): This variable specifies the PHI-coordinate of the center of the NSDth distortion region.
- c) PV(NSD): This variable specifies the total amplitude of distortion at the center of the NSDth distortion region.
- d) RRAN(NSD): This variable specifies the effective range (radius) of the NSDth distortion region with respect to the center of this region.
- e) NTYPSD(NSD): This integer variable specifies the type of distortion for the NSDth distortion region.

NTYPSD(NSD) = 0: constant, step type surface distortion

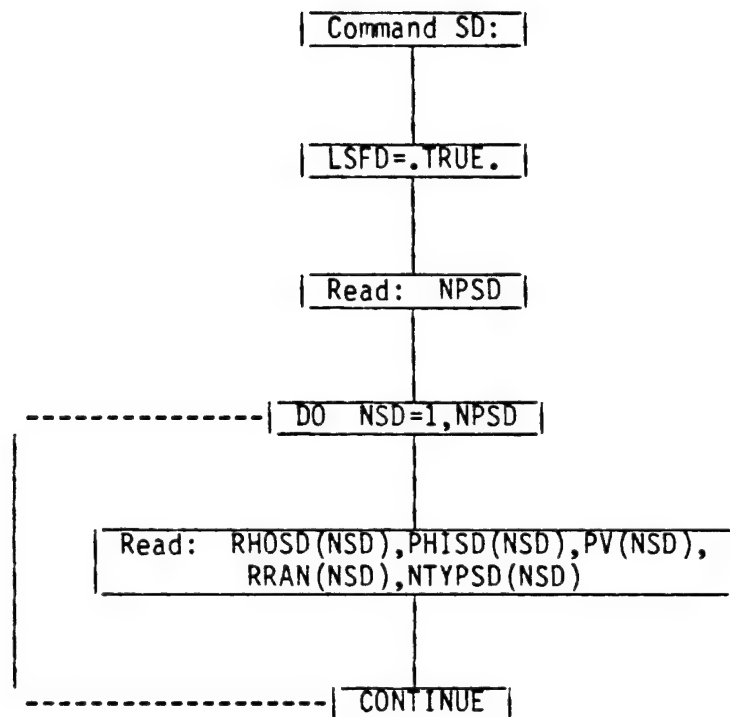
NTYPSD(NSD) = 1: Circular cone type surface distortion

NTYPSD(NSD) = 2: $\cos(\pi X/2)$ type surface distortion

NTYPSD(NSD) = 3: $\cos^2(\pi X/2)$ type surface distortion

in which X is the distance between a given point and the center of the NSDth distortion region.

BLOCK DIAGRAM FOR NONPERIODIC SURFACE DISTORTION



COMMAND PS: PLOT SURFACE PERTURBATION

This command enables the user to plot the surface perturbation or surface distortion (displacement along the normal to the ideal surface) along radial lines at any phi angles.

1. Read: NPHISF

- a) NPHISF: This integer variable is used to specify the desired number of the plots for the surface perturbation.

2. Read: (ANPS(L), L=1, NPHISF)

- a) ANPS(L): This dimensional real variable is input in degrees and defines the phi angle of the radial line for the Lth plot of surface perturbation.

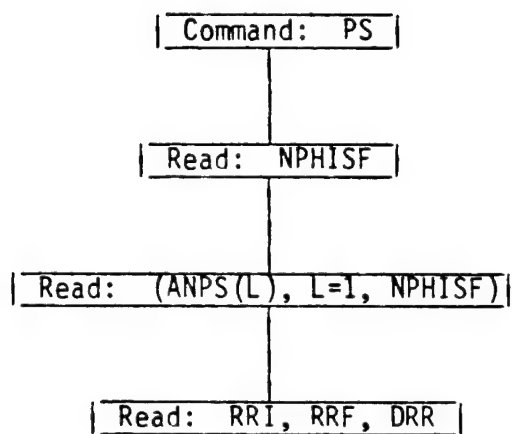
3. Read: RRI, RRF, DRR

These three variables are all input in units.

- a) RRI: This real variable defines the initial radial coordinate for the plot of the surface perturbation.
- b) RRF: This real variable defines the final radial coordinate for the plot of the surface perturbation.
- c) DRR: This real variable defines the increment in radial coordinate for the plot of the surface perturbation.

Note that the data for the plots are stored in the write unit #15 and currently the plot routine PSURF is used to plot it.

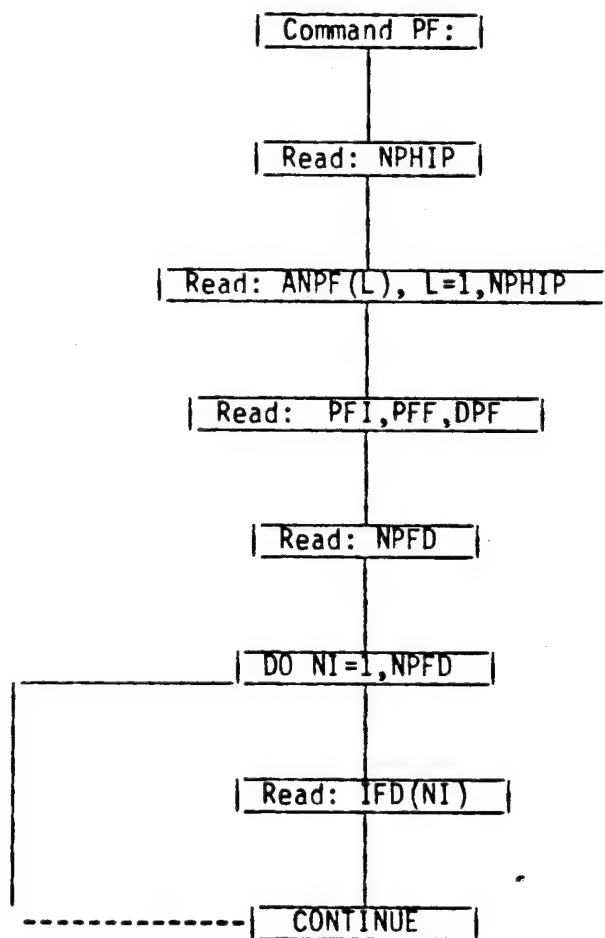
BLOCK DIAGRAM FOR PLOT SURFACE PERTURBATION



Command PF: PLOT FEED PATTERN

This command enables the user to plot feed patterns. The plot data for feed patterns is output on Unit #10.

BLOCK DIAGRAM FOR PLOTS OF FEED PATTERNS



1. READ: NPHIP

a) NPHIP: This integer variable specifies the number of PHI-cuts to be plotted for the feed pattern. Feed plot data is output on Unit #10 Presently NPHIP \leq 10.

2. READ: (ANPF(L),L=1,NPHIP)

a) ANPF(L): This dimensioned real variable defines the Lth PHI-cut for the feed pattern plot.

3. READ: PFI,PFF,DPF

a) PFI,PFF,DPF: These real variables define the initial angle, final angle, and increment in angle, respectively, for the feed pattern plots. (in degrees)

4. READ: NPFD

a) NPFD: This integer variable specifies the number of feed pattern plots for each PHI-cut. $1 \leq \text{NPFD} \leq 3$.

5. READ: IFD(NI)

This read statement is executed NPFD times.

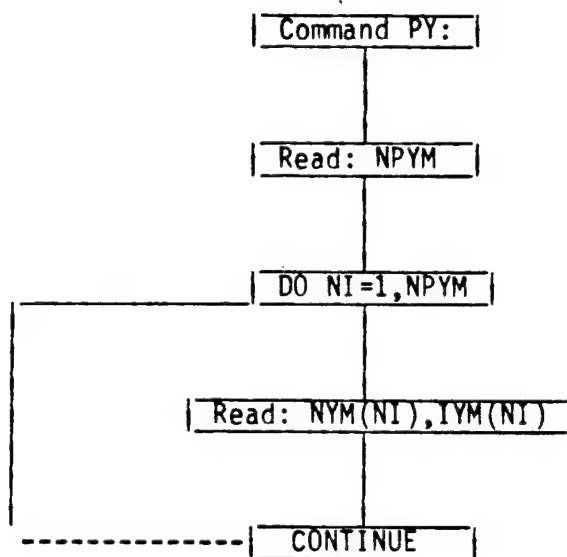
a) IFD(NI): This integer specifies the format to be plotted as follows:

1 magnitude of feed pattern.
IFD = < 2 dB value of feed pattern.
3 phase of feed pattern in degrees.

Command PY: PLOT YSUM

This command enables the user to plot YSUM data (Y-integrations used for AI). Plot data for YSUM is output on Unit #11.

BLOCK DIAGRAM FOR PLOTS OF YSUM DATA



1. READ: NPYM

- a) NPYM: This integer variable specifies the number of YSUM plots.

2. READ: NYM(NI),IYM(NI)

This read statement is executed NPYM times.

- a) NYM(NI): This integer specifies the polarization component to be plotted as follows:

N = < 1 X-component of YSUM
 2 Y-component of YSUM

- b) IYM(NI): This integer specifies the format to be plotted as follows:

I = < 1 magnitude of YSUM.
 2 dB value of YSUM.
 3 phase of YSUM in degrees.

Command PC: PLOT CSUM

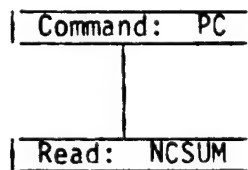
This command enables the user to plot the CSUM, which is the integrand of the x-integration at one specified far field pattern point. From that plot, the user can see how the YSUM's contribute to the total pattern value.

1. Read: NCSUM

- a) NCSUM: This integer variable is used to specify the number of CSUM plots desired. If $NCSUM < 0$, no plot is desired. If $NCSUM=4$, real and imaginary plots for both x and y components will be obtained. If $NCSUM=2$, real and imaginary plots of the y component will be obtained.

Note that the pattern point desired is specified by the PZ: command and should be restricted to one point for each run. The data for the plots are stored in the write unit #12 and currently the plot routine PCSUM is used to plot it.

BLOCK DIAGRAM FOR PLOT CSUM



Command PG: PLATE GEOMETRY

This command enables the user to define the geometry of the flat plate structures to be considered. One call to this command defines one plate. The number of plates in the structure are automatically counted by the number of calls to this command.

1. Read: MEP(MP), MEPD(MP)

a) MEP(MP): This dimensioned integer variable is used to define the number of corners (or edges) on the MPth plate.

b) MEPD(MP): This dimensional integer variable is used to define the number of edges on the MPth plate from which the diffracted fields are calculated.

2. Read: IXP(MP,MED), MED=1, MEPD(MP)
This statement is skipped if MEP(MP) = MEPD(MP)

a) IXP(MP,MED): This dimensional integer variable specifies the indicies of the edges on the MPth plate from which the diffracted fields are calculated.

3. Read: (XQ(MP,ME,N), N=1,3)

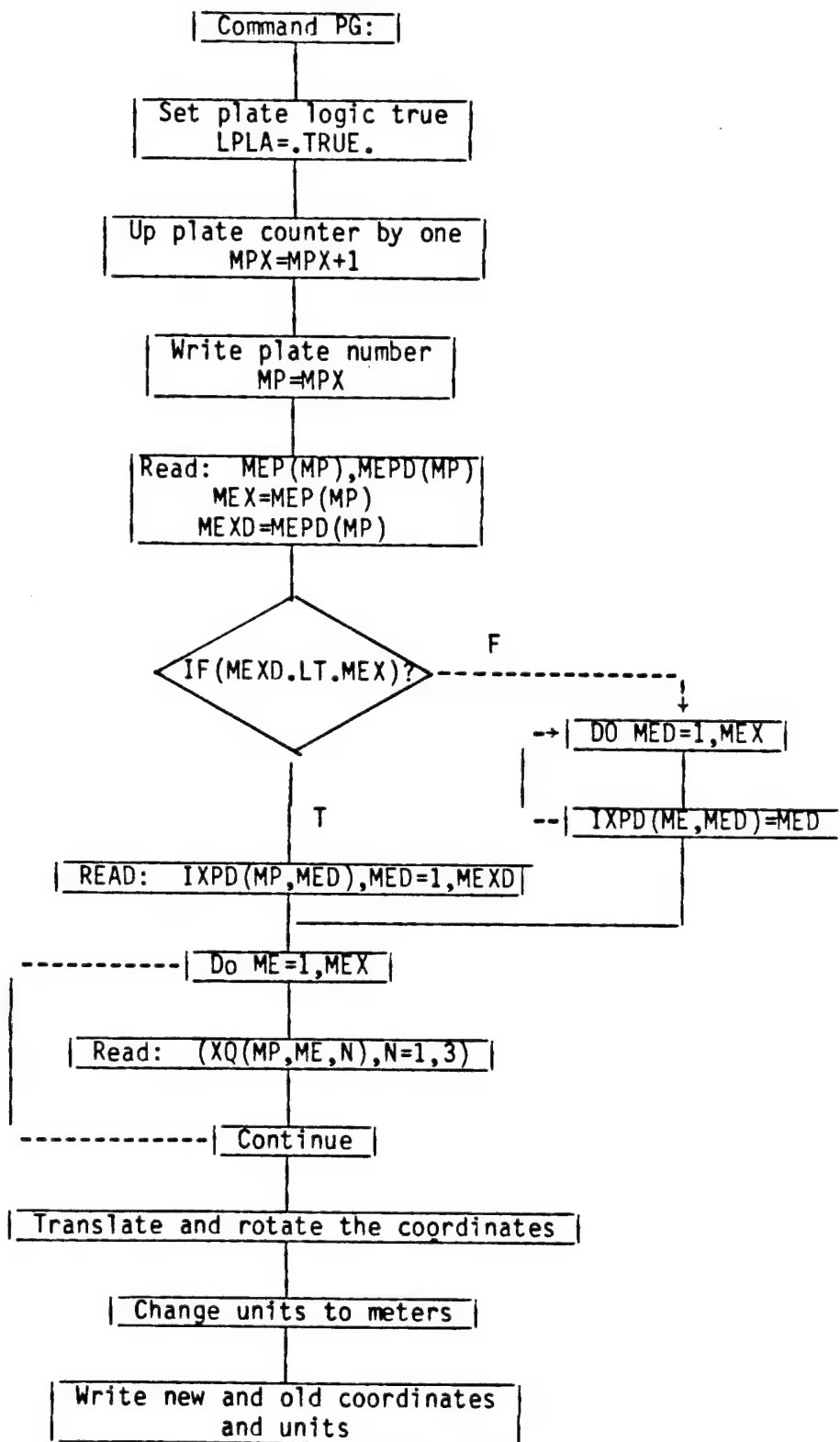
a) XQ(MP,ME,N): This triply dimensioned real variable is used to specify the location of the MEth corner of the MPth plate. It is input on a single line with the real numbers being the x,y,z coordinates of the corner, in the specified coordinate system, which corresponds to N=1,2,3, respectively, in the array. For example, the array will contain the following for plate 1 and corner 2 located at x=2., y=4., z=6.,:

XQ(1,2,1)=2.
XQ(1,2,2)=4.
XQ(1,2,3)=6.

This data is input as: 2.,4.,6.

Presently: 1<MP<5
3<ME<7

BLOCK DIAGRAM FOR PLATE GEOMETRY



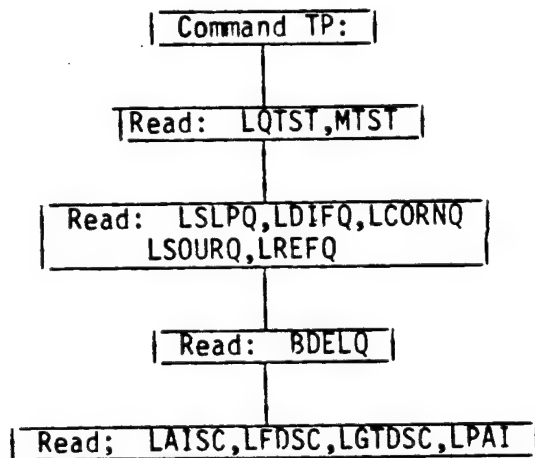
Command TP: PLATE SCATTERING

This command provides the user a test version for the plate scattering, and also enables the user to specify whether a GTD source, a primary feed source or a YSUM source model will be used for the plate scattering. The GTD and YSUM source models are illustrated in Figures 1, 2, and 3.

NOTE: When the YSUM source model is used (LAISC=true), the upper and lower edges of the scatterer should lie outside the projected aperture as shown in Figure 1.

NOTE: The user should be aware of the relative position of the plate to the reflector antenna, then choose the input variables LAISC, LGTDSC, and THETAX properly. See the notes associated with the read statements for these variables in this manual.

BLOCK DIAGRAM FOR TEST PLATE



1. Read: LQTST,MTST

- a) LQTST: This logical variable is used to determine if a test run is desired. If LQTST is set true, only a single test source which is specified by MTST is considered. This option is very helpful for the debugging. If LQTST is set false, the code will run through all of the sources as usual. (normally set false)
- b) MTST: If LQTST is true, this integer variable is used to specify which single source is under consideration. When the GTD source model is employed, MTST is the index of a single reflector rim segment. When the YSUM model is employed, MTST is the index of a single YSUM value. If LQTST is false, this input will be neglected.

2. Read: LSLPQ,LDIFQ,LCORNQ,LSOURQ,LREFQ:

These logical variables allow certain GTD diffraction terms for the plate scatterer to be suppressed for test purposes.

- a) LSLPQ: This is a proposed logical variable used to indicate if slope diffraction from the plate is desired. Since the current development does not include the slope diffraction from the plate yet, this input is neglected by the code.
- b) LDIFQ: This logical variable is used to tell the code whether or not edge diffraction is desired during the computation. (normally set true)
- c) LCORNQ: This logical variable is used to tell the code whether or not corner diffraction is desired during the computation. (normally set true)
- d) LSOURQ: This logical variable is used to tell the code whether or not the direct source field from the reflector is desired during the computation. (normally set true)
- e) LREFQ: This logical variable is used to tell the code whether or not the reflected field from the plate is desired during the computation. (normally set true)

3. Read: BDELQ

- a) BDELQ: This real variable is used in the PLATE subroutine to adjust the bounds for corner diffraction from plates. Normally, $0.5 < \text{BDELQ} < 0.8$; smaller values in this range may improve run times, at some loss of some accuracy. Presently $\text{BDELQ} = 0.8$, unless this command is used.

4. Read: LAISC,LFDSC,LGTDSC,LPAI

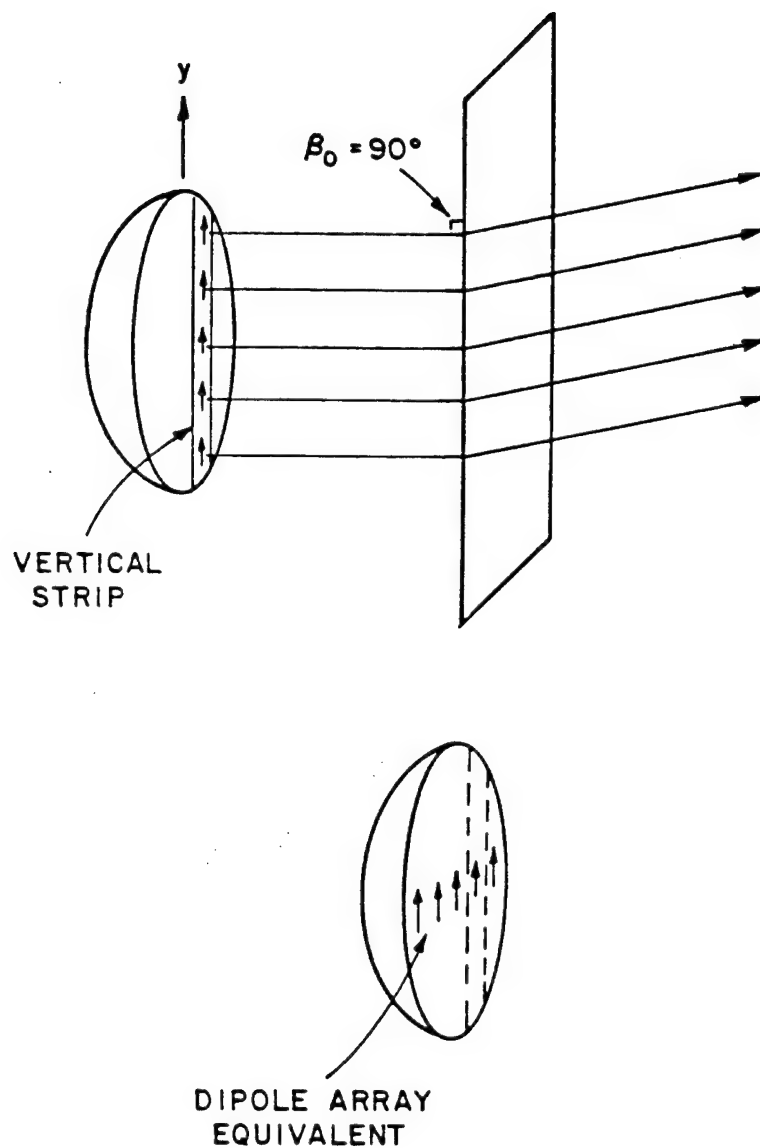
- a) LAISC: This logical variable indicates if the YSUM source model, shown in Figure 1, is desired for the scattered field. The YSUM source model should be chosen for the scattered field if part of a plate extends into the AI region of the reflector as shown in Figure 4.
- b) LFDSC: This logical variable indicates if the primary feed source model, shown in Figure 3, is desired for the scattered field.
- c) LGTDSC: This logical variable indicates if the GTD source model, shown in Figure 2, is desired for the scattered field. The GTD source model can be used for the scattered field if the plate does not extend into the AI region of the reflector as shown in Figure 4; or at pattern angles wider than 60 degrees.
- d) LPAI: This is a logical variable which is set true if the plate effect in the AI region needs to be considered. If the plate effect in the AI region is expected to be small and can be neglected. LPAI can be set false to save computer run time. (normally set true)

CONTROL of AI(YSUM), PRIMARY FEED
and GTD SOURCE MODELS for PLATE SCATTERING

The logical variables LAISC, LFDSC and LGTDSC are chosen
as shown in the following table:

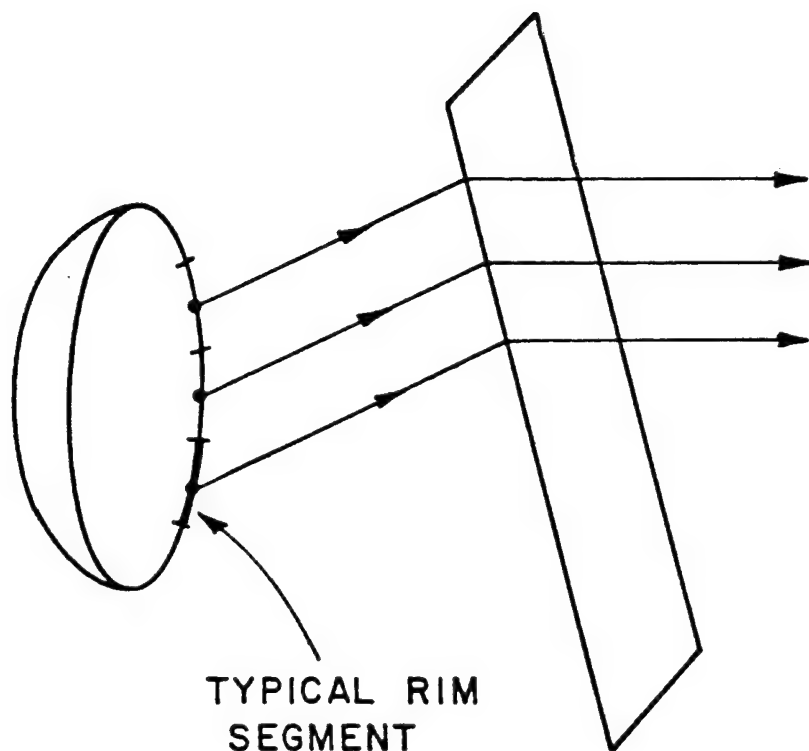
LAISC	LFDSC	LGTDSC	DECISION
F	F	F	No scattered field is desired. The program will skip the whole scattering loop.
F	F	T	Scattered field is calculated by using the GTD source model in all regions.
T	F	F	Scattered field is calculated by using the YSUM source model in all regions.
T	F	T	Scattered field is calculated by the GTD source model in the GTD region and by the YSUM model in the AI region. The regions are shown in Figure 4a.
F	T	F	Scattered field is calculated by using the primary feed source model in all regions.
F	T	T	Scattered field is calculated by using the primary feed and GTD source models in all regions.
T	T	F	Scattered field is calculated by using the primary feed and AI source models in all regions.
T	T	T	Scattered field is calculated by the GTD source model in the GTD region, YSUM source model in the AI region, and primary feed source model in all regions.

NOTE: If part of a plate extends into the AI region, then an AI source model is recommended for pattern angles near the plate shadow as shown in Figure 4b, i.e., either the YSUM source model, if satisfied, or the 2-D array source model in conjunction with the Basic Scattering Code. The GTD source model is recommended for pattern angles wider than 60 degrees even if the plate shadow extends beyond 60 degrees from the reflector axis as shown in Figure 4c. If both LAISC and LGTDSC are set true, the AI/GTD switching angle THETAX in the TO: command should be chosen carefully such that the above criterions will be met.



Y-SUM SOURCE MODEL FOR TRANSVERSE
PLANE (WORST CASE SCATTERING)

Figure 1. Y-sum source model for transverse plane (worst case scattering).



GTD SOURCE MODEL

Figure 2. GTD source model.

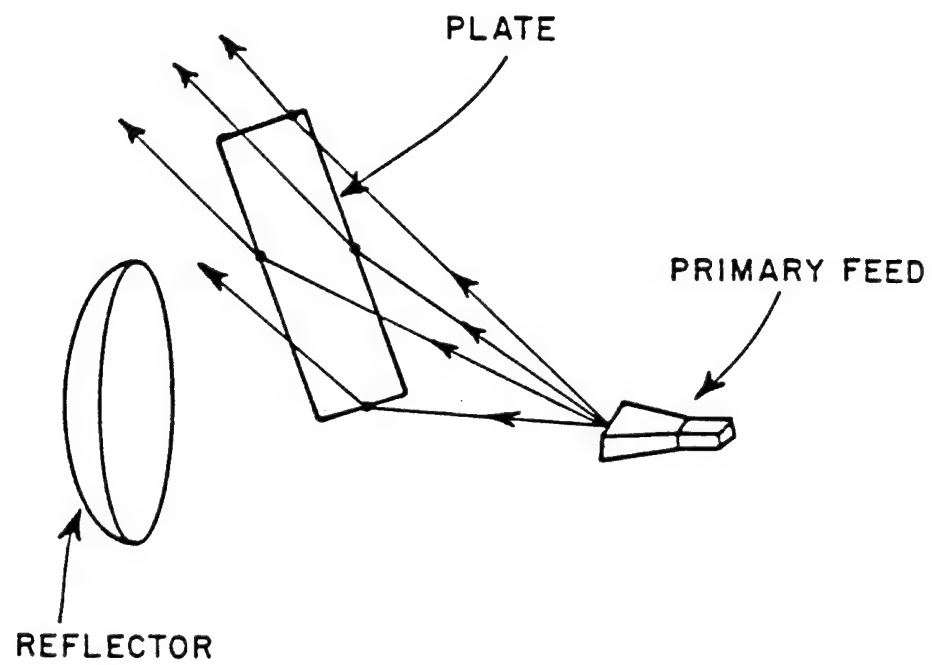
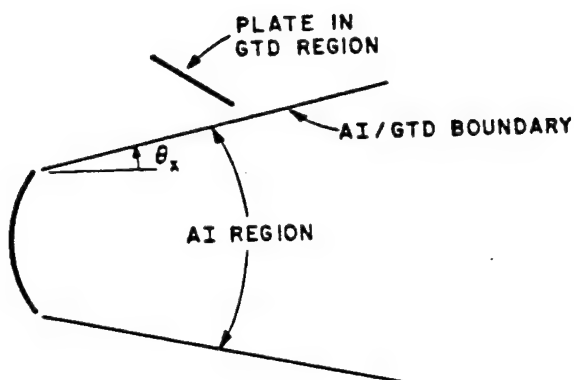
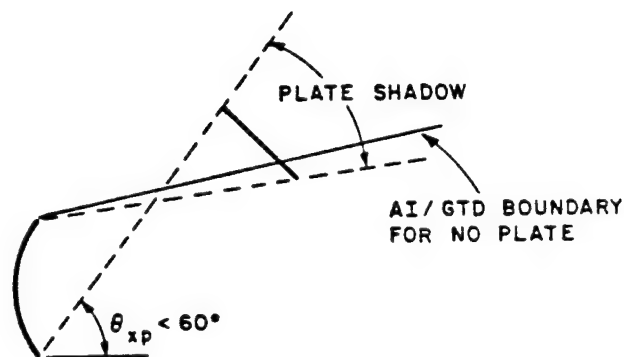


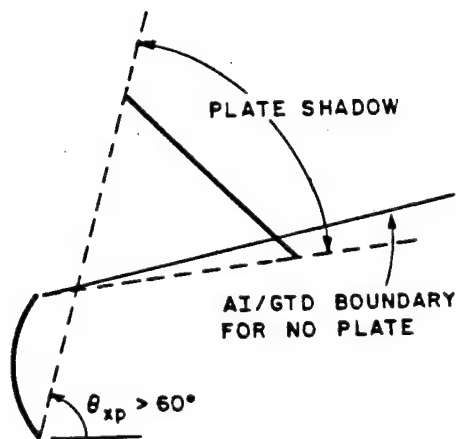
Figure 3. Primary feed source model.



(a)



(b)



(c)

Figure 4. Regions for each source model. a) Plate in the GTD region. The code uses the YSUM model in the AI region and the GTD region, unless LAISC=F or LGTDSC=F. b) Part of plate extends into the AI region adjust AI/GTD switching angle $\theta_x > \theta_{xp}$ (if LAISC=LGTDSC=T). c) Part of plate extends into the AI region and plate shadow extends beyond 60° adjust AI/GTD switching angle $\theta_x = 60^\circ$ (if LAISC=LGTDSC=T).

Example 1:

This example illustrates how the PG: command and the TP command can be used to calculate the effects of a shroud on the spillover fields of a reflector. The reflector in this example is identical to the one in example 1 of the DG: command of this supplement, i.e., a Cassegrain reflector antenna. The calculation of the subreflector pattern will not be repeated here. Only the H-plane main reflector pattern is shown here for the purpose of comparison. The geometry of the main reflector with the shroud is shown in Figure 5. The flat plate simulation of the shroud is shown in Figure 6 for the H-plane pattern calculation. Note that only the spillover fields of the feed and the edge diffracted fields from one edge of the plate (edge 2) are included in order to model the edge of the shroud. The input data for the flat plate simulation are given in Table 1.

TABLE 1

INPUT DATA FOR CALCULATING SHROUD EFFECTS

```

CM:      *** SHROUD.DAT ***
CM: EXAMPLE FOR CALCULATING SHROUD EFFECTS
CM: 2 FEET DISH WITH CONICAL HORN FEED
CM:      AND SUBREFLECTOR
CM:      DIAMETER OF HORN=1.2"
CM:      FLARE ANGLE OF HORN= 14.9 DEG.
CM:      DIAMETER OF SUBREFLECTOR=2.92"
CE:
DG:
1
3.  8.0   0.5   0.5   24.  0
FQ:
1 38.0
FD:
0      T
T      0      T      1      90.  0.  F
3      0.  45.  90.
181
0.000      0.967      8.395      -123.560      -71.142
1.000      1.082      7.778      -90.530      -46.993
2.000      1.435      6.196      -105.978      -64.826
3.000      1.956      4.145      -124.967      -161.925
4.000      2.550      2.168      -104.320      -176.473
5.000      3.121      0.639      -127.370      -17.627
6.000      3.593      -0.267      -125.602      -66.099
7.000      3.874      1.039      -131.047      -101.178
8.000      3.889      1.309      -131.781      32.642
9.000      3.826      1.901      -123.943      47.900
10.000     3.706      2.646      -121.349      50.985
11.000     3.559      3.342      -121.309      51.826
12.000     3.417      3.801      -123.247      51.218
13.000     3.311      3.897      -128.319      46.439
14.000     3.265      3.610      -141.442      -21.585
15.000     3.285      3.030      -129.788      -104.446
16.000     3.364      2.336      -125.346      -109.515
17.000     3.486      1.728      -124.394      -109.249
18.000     3.619      1.362      -125.649      -106.278
19.000     3.734      1.312      -129.968      -96.757
20.000     3.807      1.571      -138.812      -35.522
21.000     3.825      2.058      -130.777      41.253
22.000     3.785      2.646      -126.023      52.585
23.000     3.692      3.184      -124.197      56.532
24.000     3.571      3.539      -124.273      58.040
25.000     3.450      3.611      -126.224      57.473
26.000     3.353      3.363      -130.966      51.498
27.000     3.303      2.844      -141.060      -6.898
28.000     3.313      2.178      -132.596      -86.091
29.000     3.380      1.528      -127.823      -93.677
30.000     3.481      1.041      -126.098      -93.787
31.000     3.602      0.827      -126.349      -90.846
32.000     3.717      0.920      -128.378      -84.060
33.000     3.804      1.285      -132.875      -65.842
34.000     3.848      1.840      -136.967      0.533
35.000     3.842      2.470      -131.361      49.657
36.000     3.785      3.049      -127.601      63.333
37.000     3.683      3.458      -125.944      69.386
38.000     3.561      3.609      -125.737      72.702
39.000     3.437      3.449      -126.908      74.274
40.000     3.336      2.986      -129.847      72.987
41.000     3.275      2.290      -136.095      61.282
42.000     3.266      1.480      -141.183      -34.845

```

TABLE 1 - CONTINUED

43.000	3.303	0.695	-132.360	-69.240
44.000	3.384	0.076	-128.360	-72.981
45.000	3.494	-0.283	-126.469	-72.019
46.000	3.614	-0.334	-125.858	-69.028
47.000	3.725	-0.092	-126.295	-64.255
48.000	3.812	0.403	-127.713	-56.796
49.000	3.859	1.071	-130.245	-43.746
50.000	3.858	1.823	-133.655	-16.565
51.000	3.815	2.567	-134.714	31.628
52.000	3.733	3.198	-128.632	34.120
53.000	3.619	3.654	-129.169	49.483
54.000	3.483	3.859	-129.912	65.635
55.000	3.333	3.773	-130.870	83.004
56.000	3.183	3.386	-131.924	102.447
57.000	3.054	2.719	-132.968	124.615
58.000	2.960	1.831	-133.746	149.794
59.000	2.910	0.807	-133.946	176.851
60.000	2.909	-0.248	-133.464	-156.837
61.000	2.944	-1.234	-132.502	-133.476
62.000	3.016	-2.064	-131.367	-113.527
63.000	3.117	-2.672	-130.256	-96.411
64.000	3.237	-3.021	-129.255	-81.386
65.000	3.364	-3.104	-128.414	-67.817
66.000	3.480	-2.933	-127.677	-55.402
67.000	3.576	-2.536	-127.063	-43.794
68.000	3.652	-1.944	-126.558	-32.776
69.000	3.704	-1.196	-126.146	-22.209
70.000	3.729	-0.330	-125.814	-11.989
71.000	3.722	0.616	-125.551	-2.038
72.000	3.674	1.612	-125.368	7.701
73.000	3.597	2.623	-125.205	17.288
74.000	3.491	3.619	-125.076	26.756
75.000	3.357	4.575	-124.969	36.131
76.000	3.189	5.479	-124.873	45.436
77.000	2.986	6.314	-124.777	54.678
78.000	2.759	7.052	-124.671	63.841
79.000	2.509	7.679	-124.541	72.907
80.000	2.238	8.180	-124.384	81.844
81.000	1.927	8.584	-124.189	90.634
82.000	1.596	8.842	-123.951	99.207
83.000	1.247	8.946	-123.668	107.512
84.000	0.881	8.882	-123.342	115.498
85.000	0.478	8.688	-122.995	123.116
86.000	0.050	8.328	-122.580	130.361
87.000	-0.396	7.768	-122.130	137.179
88.000	-0.860	6.998	-121.649	143.556
89.000	-1.372	6.066	-121.139	149.490
90.000	-1.917	4.907	-120.607	154.975
91.000	-2.553	6.360	-119.561	149.359
92.000	-2.723	3.219	-119.100	154.484
93.000	-3.628	-1.867	-118.570	159.414
94.000	-4.930	-2.807	-117.988	163.773
95.000	-5.342	-2.113	-119.006	14.223
96.000	-5.136	-7.017	-119.575	11.252
97.000	-5.721	-14.781	-120.251	7.634
98.000	-6.789	-17.769	-120.990	3.514
99.000	-6.998	-17.620	-121.738	-1.495
100.000	-6.706	-23.629	-122.498	-7.952
101.000	-7.180	-33.313	-123.265	-15.983
102.000	-8.206	-38.625	-123.962	-25.286
103.000	-8.414	-40.311	-124.421	-35.901
104.000	-8.031	-47.854	-124.568	-47.619
105.000	-8.375	-59.257	-124.432	-59.398
106.000	-9.279	-65.931	-124.062	-69.938
107.000	-9.243	-68.409	-123.514	-78.792
108.000	-8.531	-77.667	-122.914	-86.314

TABLE 1 - CONTINUED

109.000	-8.764	-91.749	-122.402	-92.715
110.000	-10.037	-99.590	-122.080	-97.749
111.000	-10.157	-97.850	-121.902	-101.743
112.000	-8.716	-105.381	-121.907	-105.560
113.000	-8.371	-124.184	-122.205	-109.706
114.000	-10.167	-142.012	-122.904	-113.894
115.000	-12.893	-140.526	-123.966	-118.228
116.000	-11.275	-132.610	-125.354	-124.327
117.000	-8.882	-152.178	-127.265	-135.534
118.000	-8.674	176.150	-129.672	-156.274
119.000	-11.018	144.553	-131.250	170.848
120.000	-16.360	136.975	-130.103	139.199
121.000	-14.048	168.498	-127.669	121.204
122.000	-8.873	148.539	-125.472	111.054
123.000	-6.900	115.103	-124.009	103.660
124.000	-7.629	81.177	-123.420	97.961
125.000	-11.642	55.124	-123.611	94.174
126.000	-17.757	80.400	-124.398	91.478
127.000	-11.696	97.430	-125.828	87.092
128.000	-8.319	66.666	-128.393	76.540
129.000	-7.550	26.988	-132.577	48.681
130.000	-8.407	-13.563	-133.668	-11.746
131.000	-10.847	-46.476	-129.444	-46.544
132.000	-14.359	-51.909	-126.347	-57.913
133.000	-12.254	-36.506	-124.508	-62.648
134.000	-8.573	-52.061	-123.699	-66.192
135.000	-7.354	-80.123	-124.016	-70.324
136.000	-8.537	-111.299	-125.739	-75.666
137.000	-12.240	-139.766	-129.443	-84.774
138.000	-17.524	-141.113	-136.273	-118.016
139.000	-13.566	-126.662	-134.006	159.660
140.000	-7.798	-154.211	-127.847	138.908
141.000	-4.055	170.506	-124.578	131.720
142.000	-2.084	134.759	-123.171	126.337
143.000	-1.716	97.941	-123.434	120.790
144.000	-2.773	57.522	-125.637	114.372
145.000	-4.811	10.509	-130.873	102.363
146.000	-7.185	-42.313	-139.789	25.751
147.000	-10.738	-97.049	-130.656	-36.306
148.000	-18.547	166.132	-125.977	-41.811
149.000	-9.374	52.100	-123.711	-42.512
150.000	-3.399	9.179	-123.007	-43.618
151.000	-0.622	-27.103	-123.981	-47.454
152.000	0.511	-64.930	-127.491	-58.417
153.000	1.028	-106.879	-135.410	-112.772
154.000	1.773	-150.367	-128.474	164.551
155.000	2.655	169.735	-123.284	148.255
156.000	2.982	133.899	-121.297	140.515
157.000	2.346	98.230	-121.502	134.297
158.000	0.955	56.745	-124.004	126.351
159.000	0.169	6.055	-130.912	105.643
160.000	1.100	-43.307	-132.447	-2.658
161.000	2.352	-83.833	-124.636	-28.435
162.000	3.025	-121.222	-121.514	-35.673
163.000	3.603	-160.794	-120.732	-37.259
164.000	3.121	159.640	-122.514	-40.537
165.000	3.186	121.981	-127.833	-41.935
166.000	3.582	91.819	-149.018	159.574
167.000	3.284	67.246	-126.600	145.894
168.000	1.840	42.724	-121.729	145.149
169.000	-0.566	9.675	-120.158	146.036
170.000	-1.587	-38.024	-120.284	148.279
171.000	0.356	-77.615	-123.674	150.846
172.000	2.090	-100.324	-135.072	156.949
173.000	2.296	-115.463	-126.944	-33.554
174.000	0.664	-132.219	-128.067	13.192

TABLE 1 - CONTINUED

175.000	-2.889	-161.415	-121.323	65.996
176.000	-3.472	137.785	-101.095	-75.063
177.000	1.231	102.703	-111.180	-79.016
178.000	4.529	91.185	-100.571	-103.429
179.000	6.297	86.110	-91.446	58.021
180.000	6.886	84.371	-113.952	37.563
0.000	0.967	8.395	-123.048	-63.194
1.000	1.143	7.866	-38.904	157.565
2.000	1.641	6.510	-27.562	159.050
3.000	2.331	4.825	-21.518	159.313
4.000	3.054	3.313	-17.959	159.588
5.000	3.679	2.256	-16.041	159.893
6.000	4.121	1.739	-15.457	160.273
7.000	4.453	0.130	-17.175	158.870
8.000	4.440	0.398	-17.402	159.474
9.000	4.220	1.176	-20.014	160.257
10.000	3.857	2.275	-26.958	162.007
11.000	3.436	3.437	-36.132	-25.388
12.000	3.052	4.356	-23.486	-20.141
13.000	2.798	4.759	-20.143	-18.862
14.000	2.732	4.534	-19.639	-17.785
15.000	2.858	3.800	-21.386	-16.544
16.000	3.127	2.843	-26.446	-14.461
17.000	3.465	1.977	-52.327	44.052
18.000	3.786	1.408	-27.372	162.220
19.000	4.021	1.226	-22.550	164.595
20.000	4.127	1.409	-21.123	166.195
21.000	4.091	1.875	-21.842	167.810
22.000	3.925	2.497	-24.973	169.936
23.000	3.656	3.123	-33.629	175.639
24.000	3.349	3.597	-34.860	-17.874
25.000	3.066	3.783	-25.827	-11.242
26.000	2.869	3.619	-22.823	-8.811
27.000	2.802	3.152	-22.190	-6.789
28.000	2.876	2.534	-23.449	-4.626
29.000	3.065	1.956	-27.165	-1.577
30.000	3.312	1.574	-37.803	9.430
31.000	3.568	1.469	-33.920	169.660
32.000	3.782	1.640	-26.432	176.327
33.000	3.917	2.025	-23.665	179.261
34.000	3.953	2.533	-22.956	-178.282
35.000	3.886	3.053	-23.878	-175.732
36.000	3.725	3.478	-26.730	-172.471
37.000	3.491	3.708	-33.525	-165.437
38.000	3.228	3.670	-42.176	-18.272
39.000	2.977	3.340	-29.614	3.649
40.000	2.780	2.760	-25.507	8.068
41.000	2.670	2.038	-23.814	11.125
42.000	2.660	1.332	-23.586	13.933
43.000	2.734	0.796	-24.668	16.926
44.000	2.878	0.539	-27.353	20.705
45.000	3.063	0.605	-33.075	27.920
46.000	3.257	0.977	-47.750	128.511
47.000	3.427	1.581	-32.425	-166.778
48.000	3.553	2.339	-27.395	-160.205
49.000	3.614	3.149	-25.019	-156.375
50.000	3.601	3.921	-24.018	-153.154
51.000	3.522	4.561	-24.019	-150.050
52.000	3.213	5.002	-29.394	-121.519
53.000	3.033	5.483	-29.406	-101.627
54.000	2.835	5.620	-29.416	-82.155
55.000	2.629	5.394	-29.422	-63.056
56.000	2.432	4.817	-29.425	-44.351
57.000	2.271	3.936	-29.428	-26.068
58.000	2.160	2.848	-29.430	-8.191
59.000	2.106	1.676	-29.424	9.275

TABLE 1 - CONTINUED

60.000	2.110	0.551	-29.421	26.318
61.000	2.149	-0.401	-29.416	42.945
62.000	2.222	-1.106	-29.407	59.134
63.000	2.319	-1.516	-29.395	74.879
64.000	2.425	-1.617	-29.382	90.192
65.000	2.530	-1.423	-29.366	105.068
66.000	2.613	-0.955	-29.348	119.498
67.000	2.662	-0.254	-29.329	133.451
68.000	2.686	0.627	-29.308	146.951
69.000	2.680	1.643	-29.285	159.988
70.000	2.643	2.750	-29.258	172.558
71.000	2.568	3.920	-29.230	-175.348
72.000	2.445	5.136	-29.200	-163.733
73.000	2.292	6.342	-29.169	-152.602
74.000	2.110	7.511	-29.136	-141.960
75.000	1.899	8.618	-29.101	-131.810
76.000	1.651	9.662	-29.065	-122.154
77.000	1.364	10.691	-29.027	-112.998
78.000	1.054	11.595	-28.988	-104.345
79.000	0.723	12.381	-28.948	-96.200
80.000	0.372	13.038	-28.905	-88.569
81.000	-0.028	13.687	-28.862	-81.457
82.000	-0.448	14.202	-28.816	-74.868
83.000	-0.886	14.576	-28.768	-68.809
84.000	-1.341	14.801	-28.719	-63.283
85.000	-1.844	15.028	-28.667	-58.296
86.000	-2.380	15.164	-28.613	-53.847
87.000	-2.938	15.144	-28.555	-49.950
88.000	-12.344	164.489	-28.494	-46.611
89.000	-11.897	169.730	-28.428	-43.828
90.000	-11.445	174.602	-28.356	-41.609
91.000	-11.016	-175.870	-19.497	121.243
92.000	-10.541	-171.972	-16.802	38.902
93.000	-10.073	-168.410	-17.259	-36.145
94.000	-9.611	-165.177	-19.599	-129.047
95.000	-9.277	7.385	-18.958	119.218
96.000	-9.632	4.007	-16.070	38.164
97.000	-9.971	0.427	-16.373	-36.418
98.000	-10.297	-3.324	-18.501	-125.550
99.000	-10.616	-7.217	-18.497	130.934
100.000	-10.935	-11.231	-16.773	39.452
101.000	-11.264	-15.358	-15.781	-42.951
102.000	-11.614	-19.608	-16.029	-122.128
103.000	-11.999	-24.011	-18.143	152.054
104.000	-12.435	-28.629	-18.733	41.265
105.000	-12.934	-33.559	-14.999	-48.698
106.000	-13.511	-38.947	-13.771	-114.560
107.000	-14.174	-44.999	-17.045	-179.689
108.000	-14.926	-51.997	-23.175	47.780
109.000	-15.747	-60.301	-14.840	-50.512
110.000	-16.589	-70.308	-12.586	-104.933
111.000	-17.350	-82.296	-15.572	-155.503
112.000	-17.886	-96.114	-31.347	100.294
113.000	-18.070	-110.881	-17.048	-46.951
114.000	-17.887	-125.209	-13.958	-95.652
115.000	-17.464	-137.980	-16.304	-143.488
116.000	-16.981	-148.825	-26.158	153.879
117.000	-16.594	-157.980	-26.516	-29.720
118.000	-16.409	-165.950	-22.530	-102.627
119.000	-16.499	-173.324	-22.208	176.662
120.000	-16.923	179.232	-21.879	109.879
121.000	-17.727	170.867	-27.907	89.702
122.000	-18.943	160.299	-20.673	153.452
123.000	-20.494	145.445	-13.977	123.793
124.000	-21.953	123.765	-12.873	84.922
125.000	-22.359	96.297	-17.393	37.869

TABLE 1 - CONTINUED

126.000	-21.360	71.195	-23.943	-125.896
127.000	-19.886	53.391	-13.125	161.027
128.000	-18.710	41.218	-10.367	107.371
129.000	-18.097	32.077	-10.012	45.000
130.000	-18.138	24.074	-9.434	-23.032
131.000	-18.908	15.572	-9.109	-83.997
132.000	-20.516	4.273	-11.301	-144.182
133.000	-22.958	-14.596	-15.040	119.867
134.000	-25.067	-49.050	-10.014	26.587
135.000	-24.005	-89.187	-6.675	-26.338
136.000	-21.406	-113.440	-6.420	-73.276
137.000	-19.516	-126.700	-8.311	-125.962
138.000	-18.664	-135.565	-10.587	170.781
139.000	-18.865	-143.285	-12.463	111.840
140.000	-20.237	-152.437	-18.950	69.393
141.000	-23.058	-167.949	-19.962	-162.909
142.000	-26.790	155.230	-10.157	166.680
143.000	-25.593	99.698	-7.625	130.548
144.000	-21.774	72.879	-8.386	86.059
145.000	-19.455	60.856	-10.291	21.468
146.000	-18.648	53.193	-9.322	-50.572
147.000	-19.273	46.076	-8.298	-107.620
148.000	-21.603	35.912	-9.148	-171.024
149.000	-26.327	10.905	-7.247	109.496
150.000	-28.144	-60.304	-2.835	53.305
151.000	-22.661	-98.779	-0.060	12.541
152.000	-19.454	-111.230	1.071	-26.026
153.000	-18.290	-118.061	1.348	-68.206
154.000	-18.873	-124.054	1.832	-113.652
155.000	-21.564	-132.927	2.787	-155.895
156.000	-27.820	-160.568	3.396	167.843
157.000	-27.697	107.218	2.998	134.388
158.000	-21.131	79.684	1.428	98.215
159.000	-18.196	71.397	-0.686	52.274
160.000	-17.502	66.474	-1.413	-2.440
161.000	-18.863	61.436	-0.771	-51.378
162.000	-23.280	51.187	-0.501	-96.343
163.000	-32.740	-22.193	0.036	-147.008
164.000	-22.751	-93.849	-0.261	168.168
165.000	-17.927	-103.490	0.340	128.896
166.000	-16.203	-107.588	1.176	100.487
167.000	-16.688	-110.831	0.989	78.534
168.000	-19.926	-115.819	-0.656	56.283
169.000	-30.526	-143.949	-3.636	22.930
170.000	-23.418	87.685	-4.605	-31.198
171.000	-16.655	78.274	-1.747	-70.944
172.000	-14.057	75.350	0.335	-90.787
173.000	-13.824	73.536	0.602	-103.521
174.000	-12.167	75.921	-2.290	-114.182
175.000	-12.749	75.249	-9.559	-148.402
176.000	-14.669	74.782	-6.047	109.295
177.000	-18.225	74.437	1.039	91.209
178.000	-24.278	74.069	4.524	87.007
179.000	-35.629	72.724	6.287	85.284
180.000	-126.056	-140.389	6.886	84.371
0.000	0.967	8.395	-123.560	-71.142
1.000	1.210	7.958	-108.371	44.911
2.000	1.861	6.773	-108.842	-97.689
3.000	2.718	5.288	-119.681	-2.060
4.000	3.577	3.892	-126.287	-23.311
5.000	4.281	2.773	-133.494	-69.934
6.000	4.739	1.983	-126.804	-44.951
7.000	4.653	3.521	-134.996	11.195
8.000	4.618	3.677	-134.950	2.367
9.000	4.333	3.636	-135.487	-6.151
10.000	3.876	3.377	-136.588	-14.116

TABLE 1 - CONTINUED

11.000	3.349	2.914	-138.240	-20.795
12.000	2.878	2.319	-140.439	-24.253
13.000	2.581	1.743	-143.030	-20.444
14.000	2.530	1.376	-144.761	-4.316
15.000	2.714	1.343	-143.809	15.470
16.000	3.056	1.651	-141.367	24.313
17.000	3.459	2.198	-139.124	24.548
18.000	3.821	2.839	-137.477	20.746
19.000	4.067	3.444	-136.424	15.226
20.000	4.157	3.898	-135.912	8.941
21.000	4.082	4.118	-135.898	2.312
22.000	3.862	4.040	-136.341	-4.418
23.000	3.535	3.648	-137.212	-10.839
24.000	3.179	2.974	-138.470	-16.312
25.000	2.870	2.143	-140.064	-19.604
26.000	2.676	1.356	-141.846	-18.521
27.000	2.633	0.837	-143.340	-10.494
28.000	2.740	0.742	-143.623	3.359
29.000	2.955	1.098	-142.431	15.375
30.000	3.209	1.814	-140.674	21.092
31.000	3.457	2.727	-139.058	21.847
32.000	3.648	3.663	-137.819	19.738
33.000	3.748	4.465	-136.994	16.040
34.000	3.744	5.006	-136.564	11.388
35.000	3.636	5.195	-136.481	6.137
36.000	3.439	4.984	-136.715	0.529
37.000	3.180	4.376	-137.230	-5.210
38.000	2.910	3.430	-137.980	-10.746
39.000	2.673	2.289	-138.928	-15.558
40.000	2.505	1.162	-140.035	-18.869
41.000	2.427	0.275	-141.242	-19.607
42.000	2.438	-0.191	-142.407	-16.565
43.000	2.509	-0.141	-143.254	-9.104
44.000	2.624	0.409	-143.394	1.416
45.000	2.760	1.356	-142.737	11.467
46.000	2.889	2.560	-141.628	18.422
47.000	2.989	3.855	-140.459	22.011
48.000	3.045	5.099	-139.441	23.043
49.000	3.036	6.173	-138.658	22.328
50.000	2.960	6.978	-138.115	20.402
51.000	2.832	7.422	-137.787	17.568
52.000	2.441	6.683	-140.084	6.671
53.000	2.213	6.715	-140.315	6.689
54.000	1.994	6.369	-140.536	6.330
55.000	1.793	5.705	-140.739	5.655
56.000	1.624	4.806	-140.909	4.745
57.000	1.511	3.768	-141.024	3.702
58.000	1.456	2.726	-141.079	2.661
59.000	1.455	1.808	-141.082	1.751
60.000	1.496	1.116	-141.042	1.073
61.000	1.545	0.745	-140.995	0.721
62.000	1.601	0.693	-140.943	0.693
63.000	1.657	0.946	-140.891	0.971
64.000	1.701	1.477	-140.853	1.527
65.000	1.725	2.241	-140.835	2.316
66.000	1.711	3.219	-140.857	3.315
67.000	1.649	4.379	-140.928	4.494
68.000	1.554	5.634	-141.032	5.763
69.000	1.427	6.941	-141.170	7.079
70.000	1.267	8.261	-141.341	8.401
71.000	1.066	9.595	-141.554	9.732
72.000	0.811	10.973	-141.820	11.099
73.000	0.529	12.283	-142.115	12.389
74.000	0.220	13.503	-142.437	13.580
75.000	-0.113	14.612	-142.782	14.652
76.000	-0.486	15.711	-143.168	15.701

TABLE 1 - CONTINUED

77.000	-0.899	16.802	-143.593	16.732
78.000	-1.330	17.761	-144.037	17.618
79.000	-1.778	18.581	-144.495	18.352
80.000	-2.240	19.253	-144.967	18.925
81.000	-2.763	20.180	-145.498	19.738
82.000	-3.302	20.986	-146.044	20.413
83.000	-3.856	21.659	-146.603	20.938
84.000	-4.426	22.192	-147.174	21.306
85.000	-5.052	23.127	-147.800	22.052
86.000	-5.717	24.163	-148.461	22.874
87.000	-6.410	25.098	-149.146	23.563
88.000	-7.137	25.929	-149.859	24.113
89.000	-7.934	27.678	-150.640	25.524
90.000	-8.797	29.780	-151.482	27.216
91.000	-6.894	0.484	-148.344	-16.725
92.000	-18.200	-11.106	-148.576	-16.249
93.000	-10.874	77.345	-148.892	-16.462
94.000	-7.008	41.726	-149.657	-16.291
95.000	-9.582	-4.731	-149.645	-8.230
96.000	-23.772	-81.953	-148.810	-5.792
97.000	-11.906	93.435	-148.414	-8.293
98.000	-7.499	39.802	-149.023	-7.558
99.000	-8.685	-13.869	-149.105	1.380
100.000	-17.197	-89.486	-148.004	5.063
101.000	-13.145	102.643	-147.904	1.059
102.000	-7.699	39.587	-149.391	3.439
103.000	-7.980	-17.712	-149.688	18.939
104.000	-13.526	-92.381	-148.304	22.707
105.000	-13.795	124.896	-148.867	16.127
106.000	-8.428	47.382	-152.028	22.285
107.000	-8.046	-16.087	-152.133	51.304
108.000	-11.181	-92.745	-150.251	52.323
109.000	-12.637	158.138	-152.425	42.005
110.000	-10.031	68.311	-159.654	73.363
111.000	-9.498	-7.565	-154.119	119.383
112.000	-10.202	-88.751	-152.643	108.530
113.000	-10.592	-171.804	-158.388	113.013
114.000	-11.775	106.971	-155.670	-172.593
115.000	-13.215	12.420	-150.573	-177.906
116.000	-11.403	-78.644	-151.225	172.105
117.000	-10.477	-146.432	-154.686	-165.454
118.000	-13.337	150.701	-151.474	-134.857
119.000	-20.425	48.160	-149.593	-139.022
120.000	-16.017	-66.398	-151.620	-141.711
121.000	-15.061	-125.226	-154.447	-116.226
122.000	-22.027	176.509	-153.209	-96.305
123.000	-23.835	-14.532	-154.992	-93.396
124.000	-17.874	-80.593	-159.169	-48.148
125.000	-19.409	-168.018	-154.261	-18.339
126.000	-14.850	84.520	-154.579	-24.324
127.000	-10.714	17.928	-162.049	28.088
128.000	-10.145	-47.197	-151.447	69.991
129.000	-10.061	-129.731	-147.878	50.578
130.000	-7.329	151.685	-149.828	23.129
131.000	-5.465	88.954	-164.406	-38.737
132.000	-5.620	25.468	-151.496	161.625
133.000	-5.886	-50.035	-147.536	125.276
134.000	-4.199	-123.032	-149.294	80.832
135.000	-2.897	176.848	-152.505	-9.266
136.000	-3.216	118.732	-147.352	-85.919
137.000	-4.208	52.928	-145.211	-127.239
138.000	-4.089	-15.320	-147.188	-164.968
139.000	-3.911	-74.246	-154.608	133.344
140.000	-5.456	-130.236	-152.638	12.120
141.000	-8.351	159.964	-149.009	-35.315
142.000	-8.361	78.855	-151.072	-76.168

TABLE 1 - CONTINUED

143.000	-7.437	18.387	-157.705	-160.880
144.000	-9.546	-36.077	-152.278	104.122
145.000	-14.118	-123.312	-150.306	63.331
146.000	-10.246	139.402	-154.792	21.759
147.000	-7.191	79.624	-159.212	-130.381
148.000	-5.950	16.532	-148.652	173.045
149.000	-3.189	-49.164	-145.300	132.897
150.000	0.210	-100.484	-143.992	85.835
151.000	2.431	-142.558	-142.335	33.572
152.000	3.450	176.693	-140.091	-12.930
153.000	3.908	133.344	-138.407	-52.429
154.000	4.568	88.690	-137.622	-89.613
155.000	5.464	47.481	-137.447	-127.713
156.000	5.985	11.041	-137.452	-166.868
157.000	5.714	-23.198	-137.460	154.887
158.000	4.637	-58.896	-137.749	118.969
159.000	3.189	-98.981	-138.500	85.279
160.000	2.029	-142.197	-140.106	49.791
161.000	0.969	176.041	-142.455	10.842
162.000	-1.089	132.861	-145.656	-36.659
163.000	-3.617	68.768	-148.418	-108.961
164.000	-3.954	14.578	-143.697	-157.234
165.000	-2.785	-25.604	-144.035	166.474
166.000	-1.611	-52.040	-143.844	134.127
167.000	-1.739	-71.742	-143.912	106.757
168.000	-3.557	-92.097	-146.741	81.996
169.000	-7.069	-125.711	-148.707	51.470
170.000	-7.892	173.963	-149.858	7.639
171.000	-4.239	135.206	-148.471	-33.268
172.000	-1.952	117.796	-146.925	-59.668
173.000	-1.660	106.856	-146.352	-80.852
174.000	-3.881	93.067	-125.159	-119.108
175.000	-15.556	119.334	-126.578	-89.548
176.000	-5.983	-107.781	-123.165	-74.731
177.000	1.144	-100.359	-124.399	-129.605
178.000	4.542	-97.221	-102.520	111.021
179.000	6.281	-95.619	-94.737	-10.519
180.000	6.886	-95.629	-101.403	27.062

TO: LAIC=F, LGTD=F, LFEED=T

F 0. 0.
 F 0 0 0 0
 F F F F 0
 F T F 0.8
 F T F T F 0. 0.
 F F 0. 0.

PG:

4 1

2

12.05 -3.0 3.5
 12.05 -3.0 7.5
 12.05 3.0 7.5
 12.05 3.0 3.5

TP:

F 0
 T T T T F
 0.8
 F T F F

PZ:

1
 0.
 0. 180. 1
 F

PP:

1
 1 1
 1 2

XQ:

The calculated H-plane pattern of the main reflector without shroud is given in Figure 7. The pattern from the flat plate simulation is shown in Figure 8; the envelope of the measured pattern with shroud is also included. The measured pattern is shown in Figure 9. Note that the contribution from the aperture fields of the reflector are not included in the plate simulation. However, the contributions from the feed spillover and the shroud edge dominate the pattern for angles beyond 30° as can be seen from the calculated patterns in Figures 7 and 8. From this simulation, one can see the effects of the shroud on the spillover fields of the reflector.

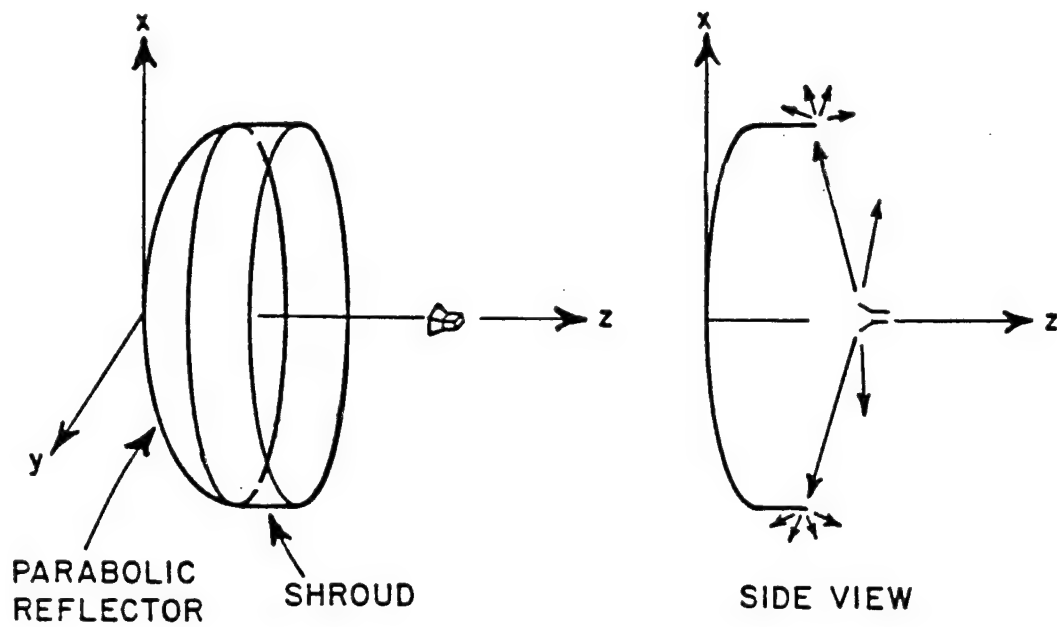


Figure 5. Geometry of reflector with shroud.

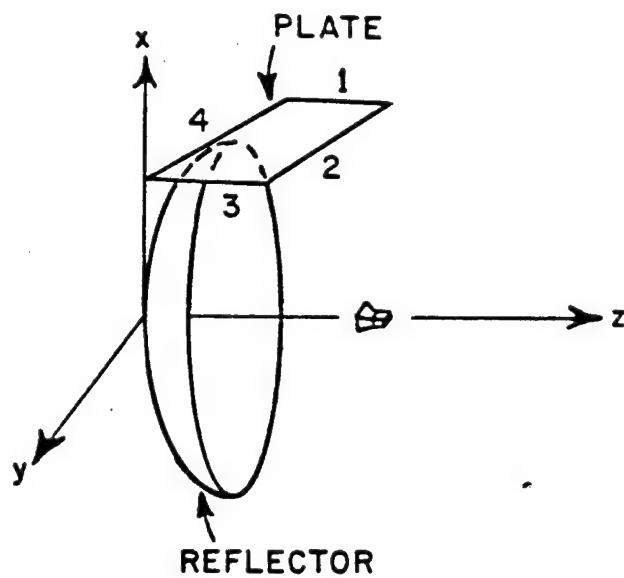


Figure 6. Geometry of reflector with one plate.

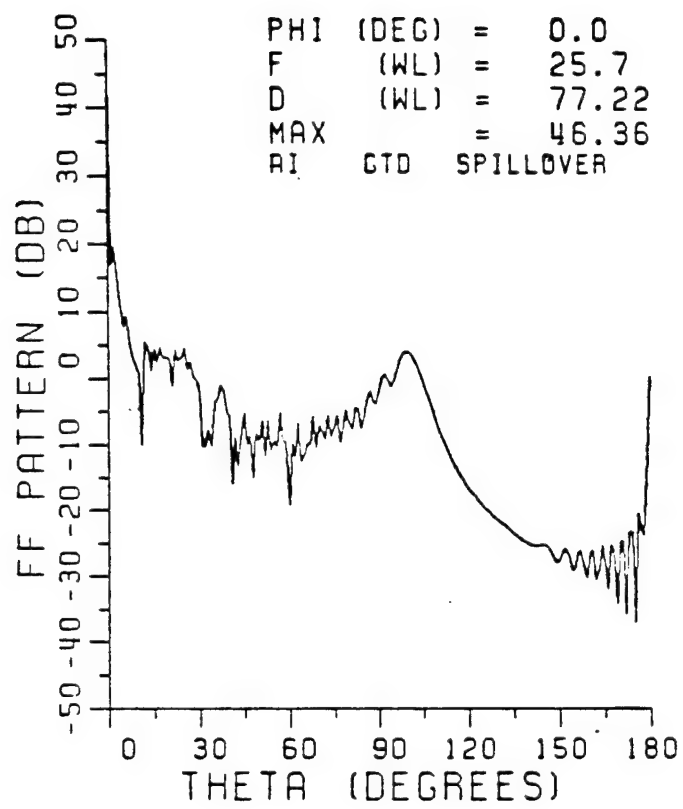


Figure 7. Calculated H-plane pattern of the reflector without plate.

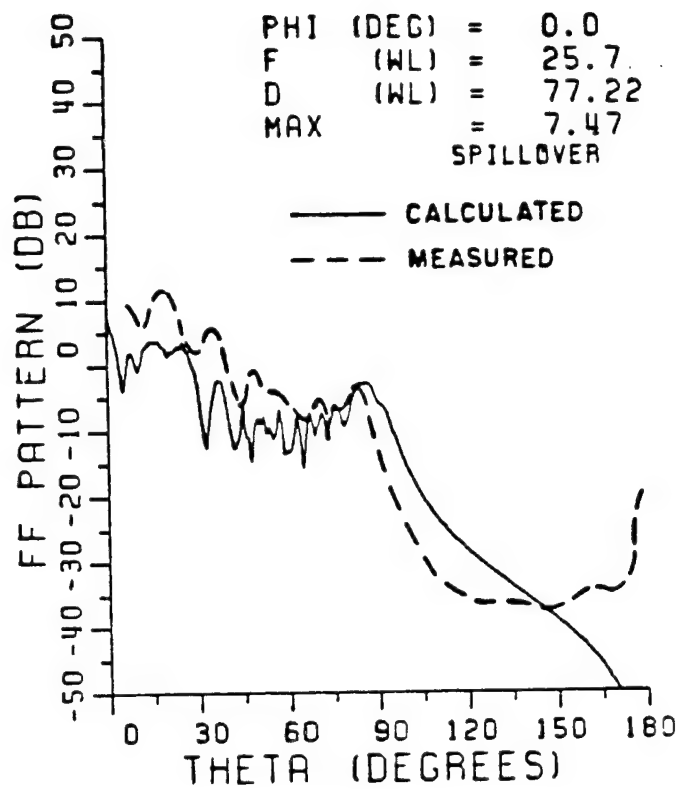


Figure 8. Calculated (solid line) pattern of flat plate simulation with comparison to the measured pattern of the reflector with shroud. (dashed line)

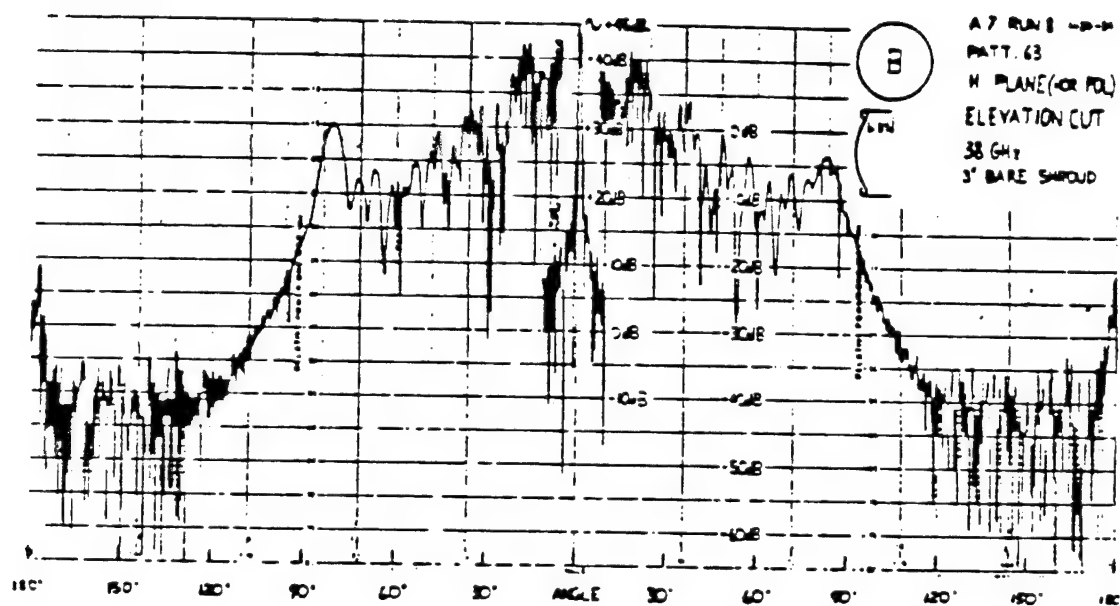


Figure 9. Measured H-plane pattern of the reflector with shroud.

Command RT: ROTATE/TRANSLATE

This command enables the user to translate and/or rotate the coordinate system used to define the input data in order to simplify input data in the PG: Command for the geometries of plate scatterers or to simplify input data in the CL: Command for linear antenna position used for coupling. The data in any PG: or CL: Command that follows RT: will be transformed. This command affects only the PG: and CL: Commands. The geometry is illustrated in Figure 1.

1. Read: (TR(N),N=1,3)

- a) TR(N): This dimensioned real variable (in input units) is used to specify the origin of the new coordinate system (referred to the reflector vertex) to be used to input the data for the plates or coupling.

2. Read: THZP,PHZP,THXP,PHXP

- a) THZP,PHZP: These real variables are input in degrees as spherical angles that define the z-axis of the new coordinate system as if it was a radial vector in the reflector coordinate system.
- b) THXP,PHXP: These real variables are input in degrees as spherical angles that define the x-axis of the new coordinate system as if it was a radial vector in the reflector coordinate system.

The new x-axis and z-axis must be defined orthogonal to each other. The new y-axis is found from the cross product of the x and z-axis. All the subsequent inputs for the PG: and CL: Commands will be made relative to this new coordinate system, which is shown as x_t , y_t , z_t , unless command "RT:" is called again and redefined.

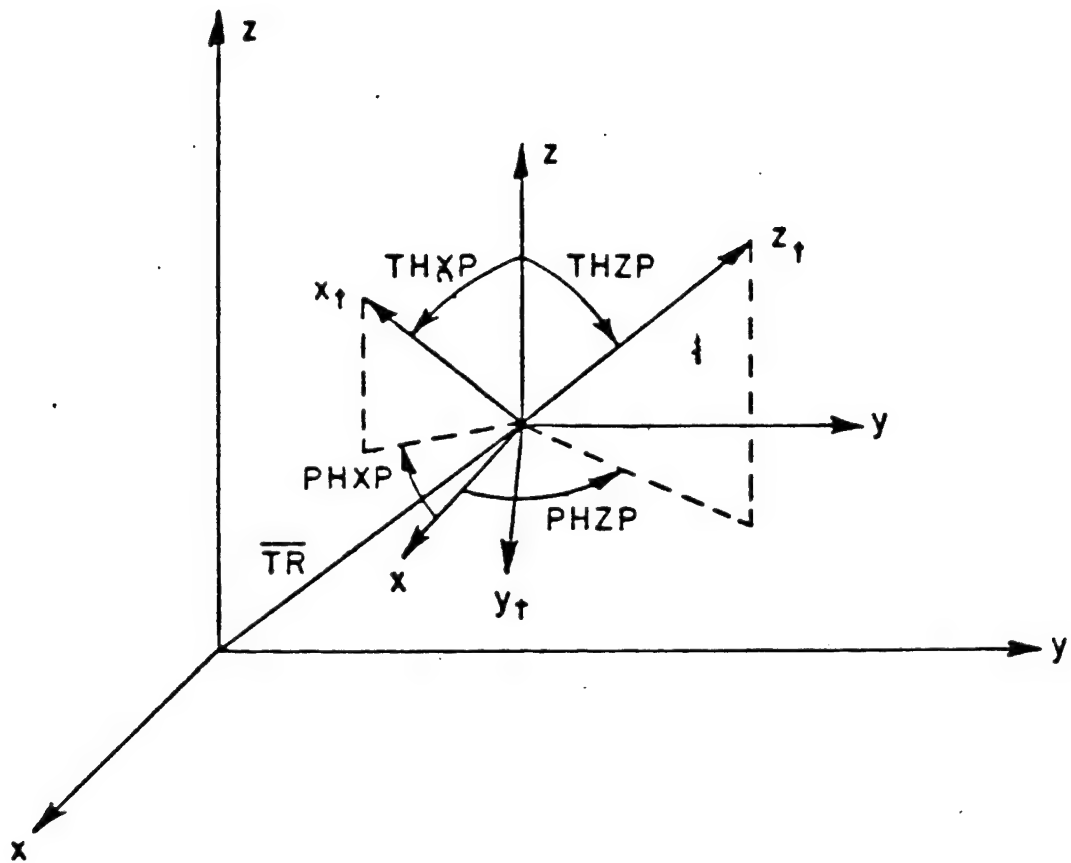
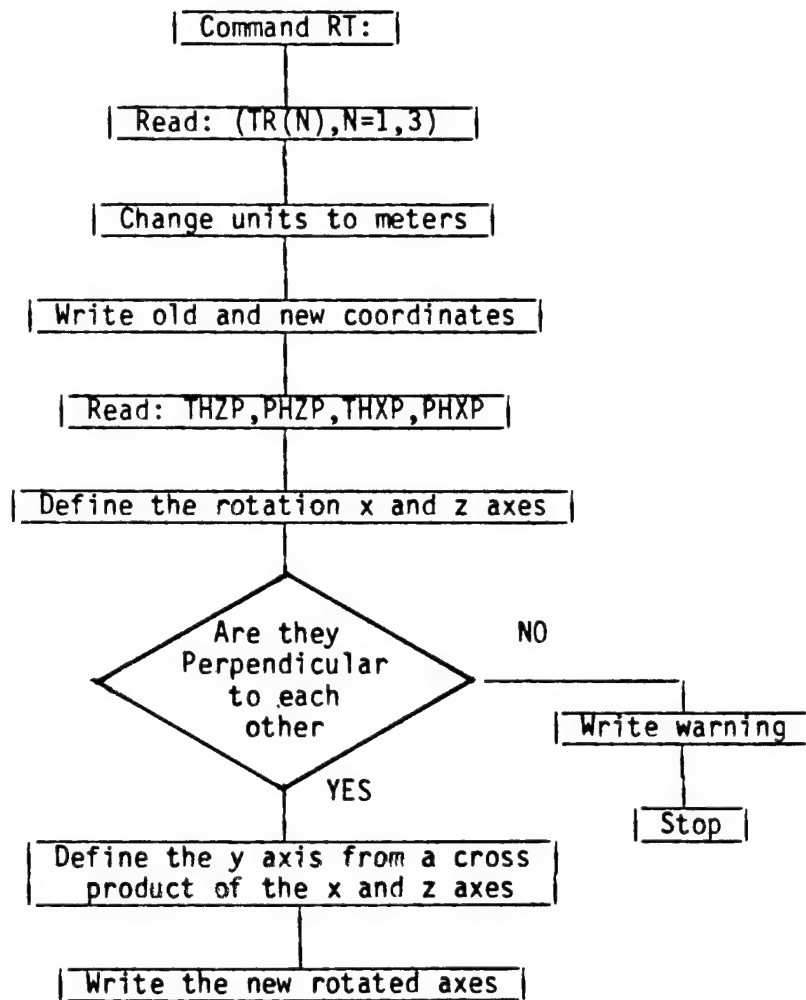


Figure 1. Definition of rotate-translate coordinate system geometry.

Block Diagram for Rotation and Translation



Command CL: REFLECTOR TO LINEAR COUPLING

This command enables the user to define a linear antenna for which the coupling to the reflector antenna can be calculated.

NOTE 1: The results from the computer code assume that both antennas are perfectly matched. The computed coupling result should be multiplied by the loss factor (mismatch in power and antenna efficiency loss) for both the receiver and transmitter.

NOTE 2: By reciprocity, the coupling between the reflector antenna and a linear antenna is the same when the transmitter and receiver are interchanged, at the same frequency. However, it should be noted that a linear antenna will typically transmit at a frequency below the cutoff frequency of the reflector feed system. Thus, the impedance mismatch will usually cause very low coupling from linear to reflector. The linear antenna will typically receive the transmitted signal from the reflector antenna at a higher coupling level because of less impedance mismatch.

1. Read: NLA

a) NLA: This integer variable is used to define the number of points on the linear antenna at which the incident field from the reflector is to be calculated for reaction with the currents on the linear antenna. If NLA=1 the incident field of the reflector is calculated only at the midpoint of the linear antenna. Presently $1 < NLA < 901$.

2. Read: (XLA1(N),N=1,3)

a) XLA1(N): This dimensioned real variable defines one end-point of the linear antenna.

3. Read: (XLA2(N),N=1,3)

a) XLA2(N): This dimensioned real variable defines the other end-point of the linear antenna which should be different from XLA1(N), even for NLA=1.

4. Read: NPN,LWCLA

- a) NPN: This integer variable is used to specify the number of linear antenna locations desired. Presently $1 < \text{NPN} < 1842$.
- b) LWCLA: This logical variable, if set true, is used to output the end-point coordinates of the linear antenna at all NPN locations. If set false, only the data for the initial location is output. (normally set false)

5. Read: LRECT

This statement is skipped if $\text{NPN}=1$.

- a) LRECT: This logical variable, if set true, specifies the linear antenna to move along rectangular coordinates. If set false, the reflector antenna is rotated ($\text{LROT}=\text{true}$) or tilted ($\text{LROT}=\text{false}$); so that the linear antenna moves along spherical coordinates relative to the reflector antenna.

LRECT=TRUE	TRANSLATE LINEAR ANTENNA ALONG RECTANGULAR
	COORDINATES
LRECT=FALSE	ROTATE OR TILT REFLECTOR ANTENNA

6. Read: (XRECI(N),N=1,3)

This statement is skipped if $\text{NPN}=1$ or $\text{LRECT}=\text{false}$.

- a) XRECI(N): This dimensioned real variable defines the increment vector for $\text{LRECT}=\text{true}$.

7. Read: LROT,(XRTC(N),N=1,3),ANGI

This statement is skipped if $\text{NPN}=1$ or $\text{LRECT}=\text{true}$.

- a) LROT: This logical variable is used to specify rotation or tilt of the reflector. If set true, the reflector is rotated. If set false, the reflector is tilted.

LROT=TRUE	ROTATE REFLECTOR ANTENNA
LROT=FALSE	TILT REFLECTOR ANTENNA

- b) XRTC(N): This dimensioned real variable defines the center of rotation or tilt for the reflector (referred to the reflector vertex).
- c) ANGI: This real variable defines the increment in degrees for rotation or tilt of the reflector.

8. Read: LINCON

- a) LINCON: This logical variable, if set true, provides for the calculation of the incident field from the reflector antenna (at NLA points between XLA1 and XLA2) without the calculation of coupling. If set false, coupling is calculated. (normally set false)

LINCON=TRUE CALCULATE INCIDENT FIELD FROM THE REFLECTOR
 ANTENNA
LINCON=FALSE CALCULATE COUPLING

9. Read: WMR(NN),WPR(NN)

This statement is skipped if LINCON=true. This read statement is executed NLA times.

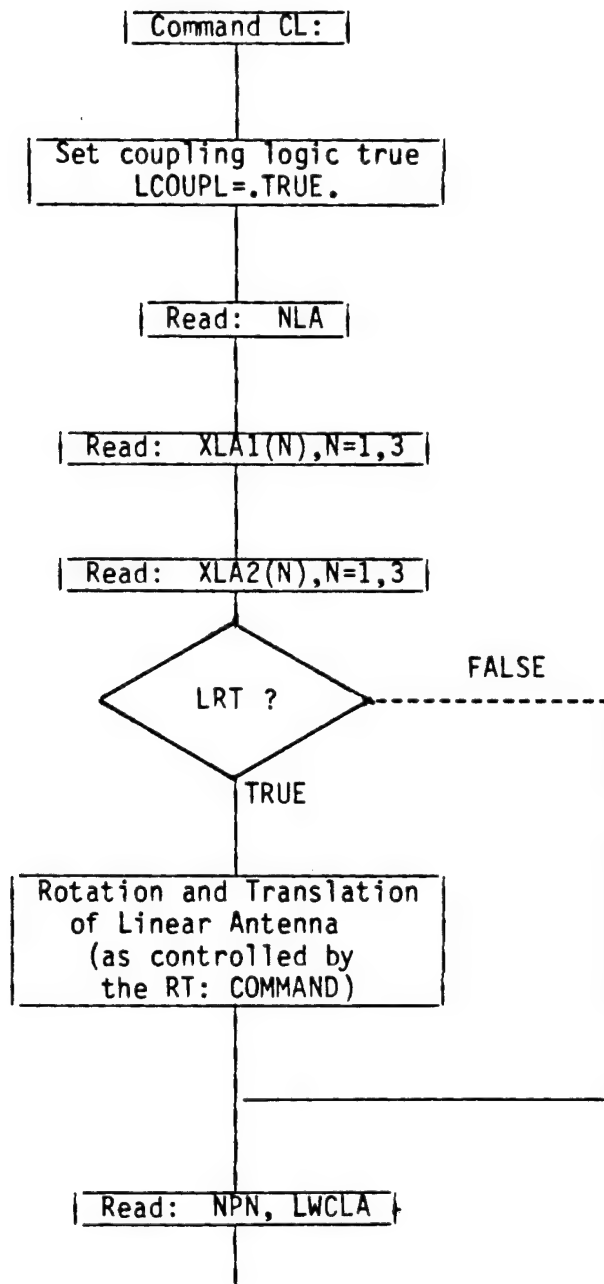
- a) WMR(NN): This dimensioned real variable defines the magnitude of the current distribution on the linear antenna, at NLA uniformly spaced points.
- b) WPR(NN): This dimensioned real variable defines the phase of the current distribution on the linear antenna, at NLA uniformly spaced points.

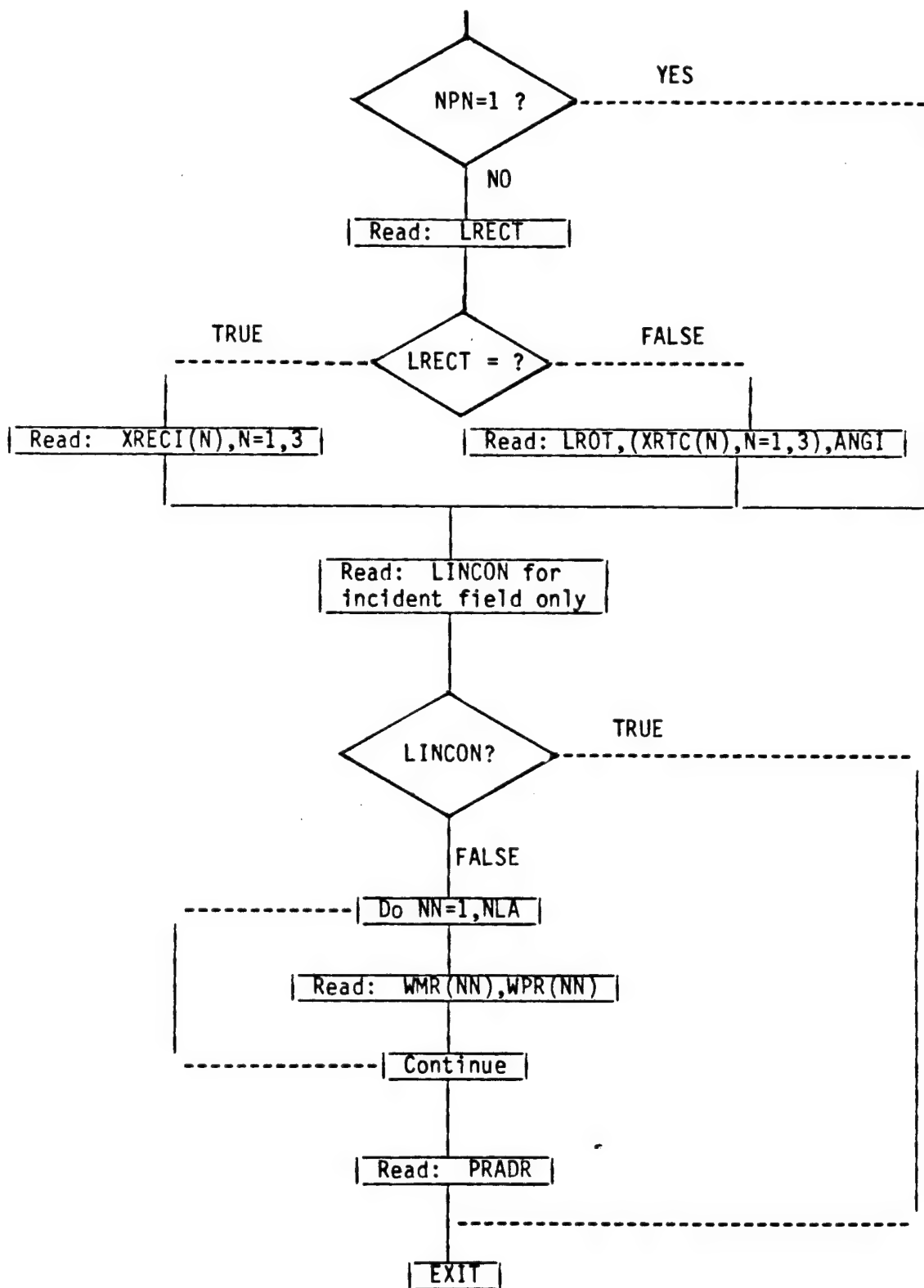
10. Read: PRADR

This statement is skipped if LINCON=true.

- a) PRADR: This real variable specifies the radiated power from the linear antenna when it transmits with the currents specified for coupling calculations.

FLOW DIAGRAM





Command NR: NRUN OPTION (STORE YSUM DATA FOR NEXT RUN)

This command enables the user to store the YSUM data when the aperture integration is used. The stored YSUM data can be used for the next run when the parameters of the reflector system such as grid size, frequency and diameter are not changed. This option is useful since it saves the CPU time in calculating the aperture fields and the YSUM data, especially when strut scattering, feed blockage and plate scattering are included in the pattern calculation. One can input different geometries of struts and plates to obtain the total pattern without recalculating the aperture fields and YSUM data. Note that only one ϕ -cut is allowed when this command is used since the YSUM data are different for different ϕ -cuts.

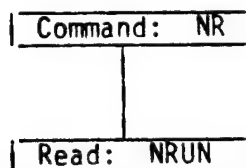
1. Read: NRUN

- a) NRUN: This integer variable specifies whether the aperture index of the integration data is to be stored for future use, or read from a previous output file.

NRUN = 1: The YSUM data are stored in unit #21.

NRUN = 2: The YSUM data are read from unit #21.

BLOCK DIAGRAM FOR NRUN OPTION

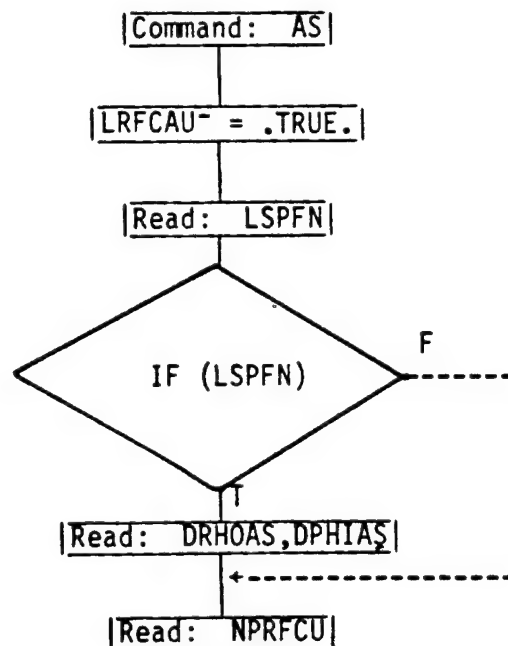


Command AS: SPREAD FACTOR CALCULATION FOR G.O. FIELD

This command enables the user to specify whether the spread factor calculation for the Geometrical Optics (G.O.) field is used or not. For focused parabolic reflectors, the spread factor for the G.O. field is unity so that this command is not necessary. For defocused parabolic reflectors or other reflectors such as hyperbolic or elliptic reflectors, the spread factor is not unity so that this command can be used to calculate the spread factor.

A numerical method or an analytic method can be used to calculate the caustic distance of the reflected field and its associated spread factor. The choice is specified by the logical variable LSPFN. With the numerical method, two points adjacent to the reflection point are used to calculate the caustic distance of the reflected field for each of the RHO- and PHI-directions. With the other option, an analytic expression is used for the caustic distance.

BLOCK DIAGRAM FOR SPREAD FACTOR CALCULATION



1. Read: LSPFN

- a) This logical variable specifies whether the numerical or the analytic method is used to calculate the reflected field caustic distance. If LSPFN=T, the numerical method is used. If LSPFN=F, the analytic expression is used.

2. READ: DRHOAS, DPHIAS

This read statement is used only for LSPFN = T.

- a) DRHOAS: This variable specifies the distance (in wavelengths) from the reflection point to the two adjacent points for the RHO-direction.
- b) DPHIAS: This variable specifies the angle (in degrees) from the reflection point to the two adjacent points for the PHI-direction.

3. READ: NPRFCU

- a) NPRFCU: This variable specifies that the spread factor will be re-calculated for every NPRFCU field point. For example, if NPRFCU = 4, the spread factor is calculated for every 4th point; and the same value is used for the following 3 points.

Command RF: REFLECTOR ROTATION AND TILT

This command enables the user to rotate and/or tilt the reflector antenna without changing the input of the near field points, plate or coupling geometry, so that the specification of the geometry is simplified. It is useful when the near field points, the plate scatterer or the linear antenna (for coupling) is fixed and reflector needs to be scanned. The geometry is illustrated in Figure 1.

1. Read: LRFRL, LRFRT, LRFTL

- a) LRFRL: This is a logical variable specified by T or F. If set true, the reflector may be rotated about Z-axis.
- b) LRFRT: This is a logical variable specified by T or F. If set true, the reflector may be rotated in azimuth.
- c) LRFTL: This is a logical variable specified by T or F. If set true, the reflector may be tilted in elevation.

2. Read: ANGRL

- a) ANGRL: This real variable defines the angle of rotation about the z-axis with respect to the x-axis.

3. Read: XORT(I), I=1,3, ANGRT

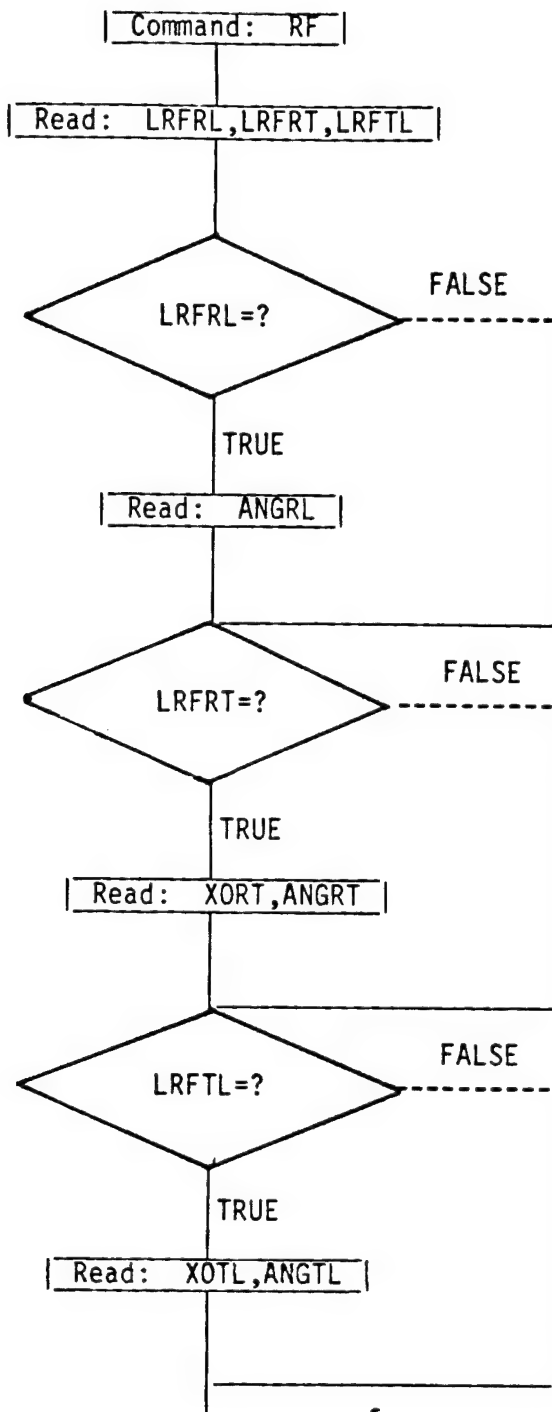
This statement is skipped if LRFRT is false.

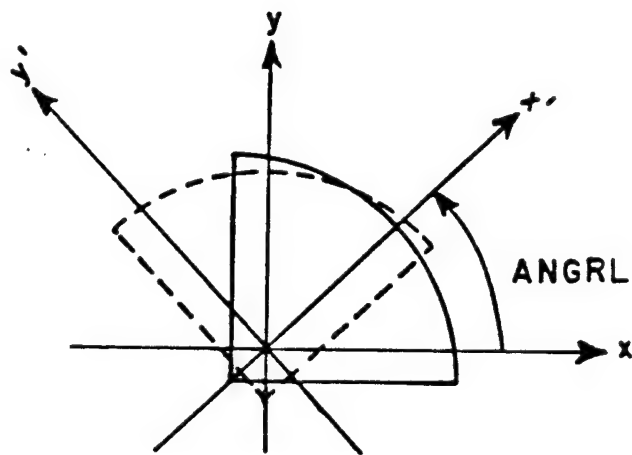
- a) XORT: This dimensioned real variable defines the coordinate of the rotation center.
- b) ANGRT: This real variable defines the rotation angle in degrees.

4. Read: XOTL(I), I, ANGTL

This statement is skipped if LRFTL is false.

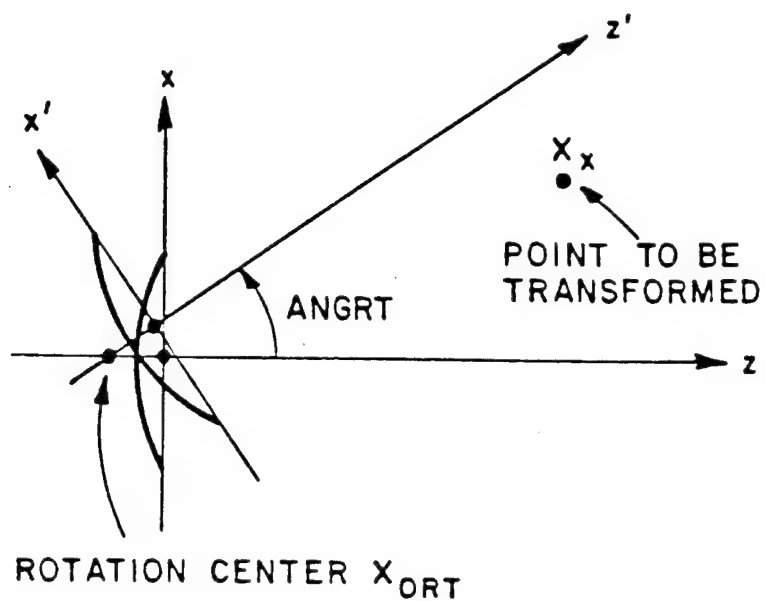
- a) XOTL: This dimensional real variable defines the coordinate of the tilt center.
- b) ANGTL: This real variable defines the tilt angle in degrees.



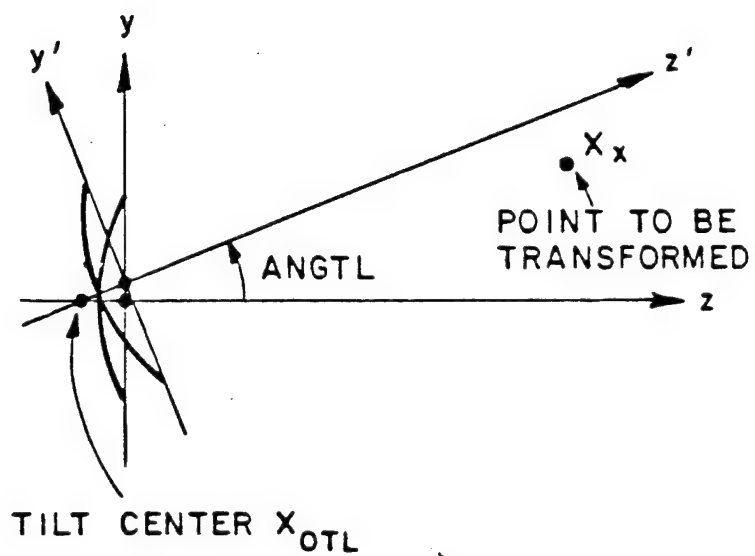


(a) Rotation about z -axis

Figure 1. Geometry for the rotation.



(b) Azimuth rotation



(c) Elevation tilt

Figure 1. Continued.

Command CK: CRACK SCATTERING

This command specifies the geometry of thin cracks in the reflector surface. Each crack is assumed rectangular in shape and can be divided into small sections. Each section will be considered as an individual crack inside the code and can be further subdivided into small segments.

The axis of each crack is straight; however, a piecewise linear crack can be modeled by joining several cracks at their end-points. In such a case, the coordinates of the end point at each junction will be input as end-points for both adjacent cracks.

1. Read: NCK,GRCK,THECK,LWSAME,LNGSAM

- a) NCK: This integer variable specifies the number of cracks. Presently, $NCK \leq 108$.
- b) GRCK: This real variable specifies the size of the segment used in subdividing a section of each crack. The grid size GRCK (input in units) controls the number of segments into which each section is subdivided, and should not exceed 0.5 wavelengths. Presently, a maximum of 63 segments can be used on any crack section.
- c) THECK: This real variable is used to adjust the maximum theta angle for which crack scattering is included.
- d) LWSAME: This logical variable specifies whether all the cracks have same width or not. If LWSAME is true, the crack width is input only once.
- e) LNGSAM: This logical variable specifies whether all cracks are divided into the same number of sections or not. (Note that each section can be further subdivided into small segments by the variable GRCK).

2. Read: RHCKU,PHICK(M,J)

This statement is executed twice for the end-points ($J=1,2$) for each crack (strut #M). The coordinate system is cylindrical, referred to the vertex of the reflector as shown in Figure 1.

- a) RHCKU: This real variable specifies the rho-coordinate of the j^{th} end point on the M^{th} crack.

- b) PHICK(M,J): This is a real variable specifying the phi-coordinate (in degrees) of the end-points (J=1,2) on the Mth crack.

3. Read: NCC(M)

- a) NCC(M): This integer variable specifies the number of sections into which crack M is to be subdivided. (This is useful for cracks which are too long to be subdivided into sufficiently small segments because the number of segments would exceed that allowed by the dimensioned variables. Presently, 63 segments are allowed per section.)

If LNGSAM=T, this variable is read only for the first crack (M=1). Note that the maximum number of subdivided sections for all the cracks is 108. An example with 3 sections is given in Figure 2.

4. Read: WPU:

This statement is executed for the first crack if all cracks have the same width (LWSAME=T). If LWSAME=F, this statement is executed for each crack.

- a) WPU: This real variable specifies the width of the Mth crack. The maximum width of the crack should not exceed 0.1 wavelength.

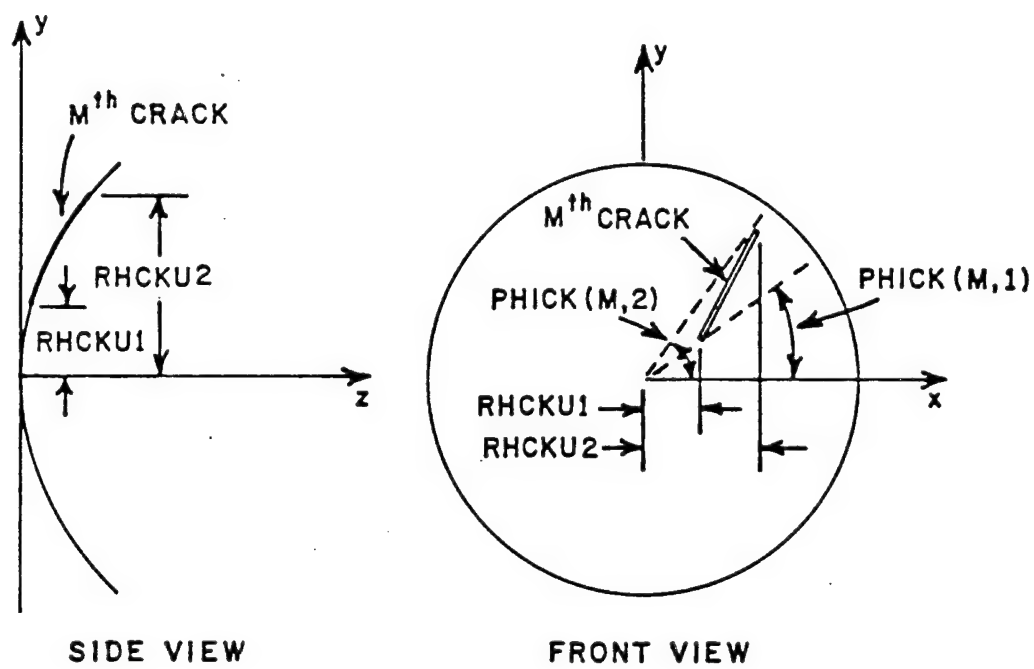


Figure 1. Coordinate system for the end points of the M^{th} crack.

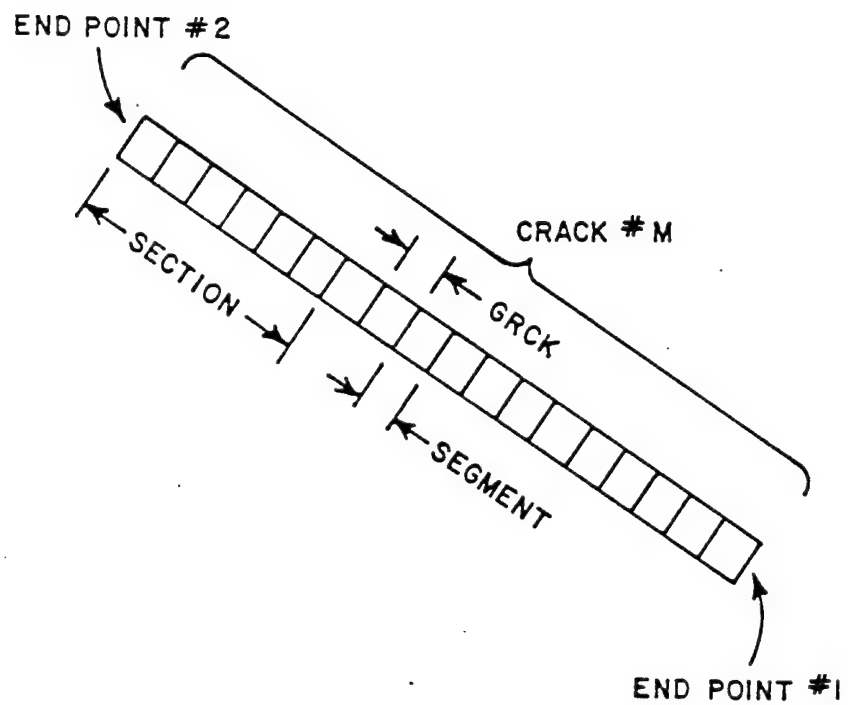


Figure 2. Example of a crack divided into 3 sections $NCC(M)=3$. In this particular example each section is divided into 6 segments by the choice of GRCK.

Command BS: DATA FOR NEC-BSC

This command enables the user to use the NEC Basic Scattering Code [11] to handle more complicated scatterers, such as cylinders, in the near field of the reflector antenna. Two models have been developed for use with the Basic Scattering Code, namely, the YSUM model and the 2-dimensional array model. If either model is used, the reflector code will generate SG:, XQ:, and EN: commands for the Basic Scattering Code input and store it in the write Unit #2. The user should include these commands in his input file for the Basic Scattering Code.

1. Read: LBS1,LBS2,HS

- a) LBS1: If this logical variable is set true the YSUM model is used. Since the YSUM model treats a Y-integration equivalent line source as a single dipole source, this model is quite efficient but restricted to the cases where the plate or cylinder scatterers are long with their axes vertically oriented and the far field pattern is in the PHI= 0 plane. The upper and lower edges of the scatterer should lie outside the projected aperture as shown in Figure 1 of the TP: Command.
- b) LBS2: If this logical variable is set true (and LBS1 is set false) the 2D array model is used. With this model the reflector is represented as a 2D dipole array source which uses the aperture field over the reflector grid. Note that although this model is more accurate than the YSUM model, it is very time consuming because a large number of sources must often be used. Currently the maximum number of sources is limited to 30 by the array dimension of the Basic Scattering Code.

NOTE: LBS1 and LBS2 should not be true at the same time. If that happens, the YSUM model will be used.

- c) HS: This real variable is used to input the length of all the dipole elements. The unit of HS is specified by the US: Command of the Basic Scattering Code. Usually, HS=0.2 wavelength is a good choice.

NOTE: The BS: Command capability is currently restricted to y-polarized electric fields in the aperture, i.e., TAU= 90° in the FD: Command.

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APPENDIX A

ANALYTIC FUNCTIONS FOR FEED PATTERNS

The reflector antenna code uses either a piecewise linear feed pattern, or the analytic functions described below. For sum patterns, the analytic function is given by

$$f_{\Sigma}(\psi) = \frac{e^{-A\left(\frac{\psi}{\psi_0}\right)^2} \left[\cos N \left(\frac{\pi\psi}{2\psi_0} \right) \right] + C}{1 + C} \quad \text{ISYM} > 0 \quad (\text{A.1})$$

where the constants A, ψ_0 and C can be controlled for each input pattern cut ψ_n . The pattern value in Equation (A.1) is normalized such that $f_{\Sigma}(0)=1$ for all ϕ -plane cuts. The constants A, C and N control the shape of the pattern. The constant ψ_0 permits a given pattern shape to be stretched or compressed.

For large values of $\frac{\psi}{\psi_0}$, $f_{\Sigma}(\psi) \rightarrow \frac{C}{1+C}$. In many cases, this represents a spillover level that is too high for typical feed patterns. Consequently, the feed subroutine uses a linear taper under certain conditions for $\psi_{L1} < \psi < \psi_{L2}$ as shown in Figure 1, where ψ_{L1} and ψ_{L2} are input in the FD: Command and are controlled by logical variable LPSIL. If LPSIL=F, Equation (A.1) is used for the entire feed pattern cut.

For difference feed patterns, the analytic function is given by

$$f_{\Delta}(\psi) = C e^{-A\left(\frac{\psi}{\psi_0}\right)^2} \sin N \left(\frac{\pi\psi}{2\psi_0} \right) \quad \text{ISYM} < 0 \quad (\text{A.2})$$

for the entire feed pattern cut.

The parameters in Equations (A.1) and (A.2) correspond to the following input variables used in the code. Refer to the FD: Command.

<u>Parameter</u>	<u>Code Name</u>
N	NPW
A	AEX
C	CAN
ψ_0	PSIO

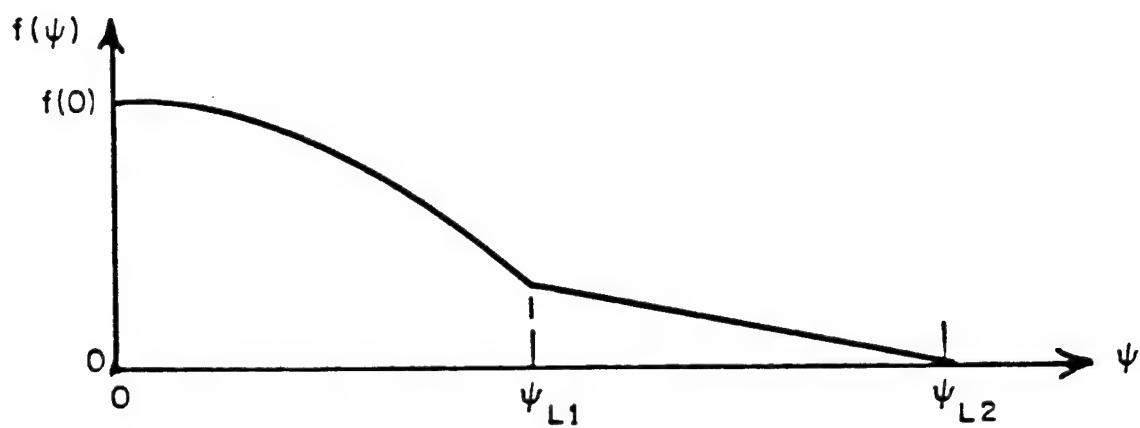


Figure 1. Analytic feed pattern with linear taper region.

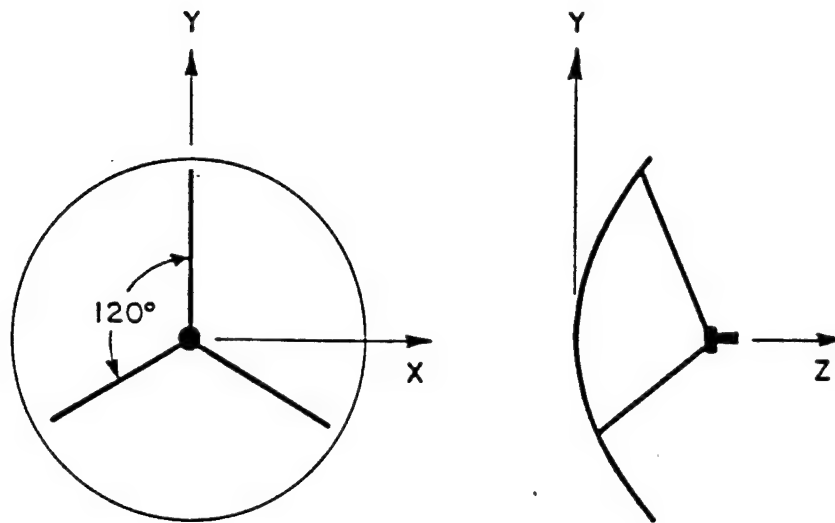
APPENDIX B

EXAMPLES OF A 24" FOCAL POINT REFLECTOR

In this section, several examples of a 24" focal point parabolic reflector antenna are given to show how the basic commands are used to calculate the patterns of the antenna. The geometry of this reflector with an on-axis feed is shown in Figure 1. Calculated results are given for a frequency of 11.0 GHz. A GTD analysis was previously developed for the far field pattern of this circular reflector as reported in Reference [12].

EXAMPLE 1

This example shows the default case of the Reflector Antenna Code. A 24" circular reflector antenna with 8" focal distance is chosen as the default reflector, and a focused feed with an analytic feed pattern (LLFD=F) is chosen as the default feed. Feed blockage, strut and plate are not included in the default case. The only input needed to run this case is the XQ: Command. The line printer output is shown in Table 1. Note that a 5° increment is used in the line printer output. Normally, about a 0.5° increment would be used for plotting purposes. The plot of the H-plane pattern is shown in Figure 2. To obtain this plot, one has to input PZ: and PP: Commands before the XQ: Command.



(a) FRONT VIEW

(b) SIDE VIEW

Figure 1. Circular reflector antenna with an on-axis feed.

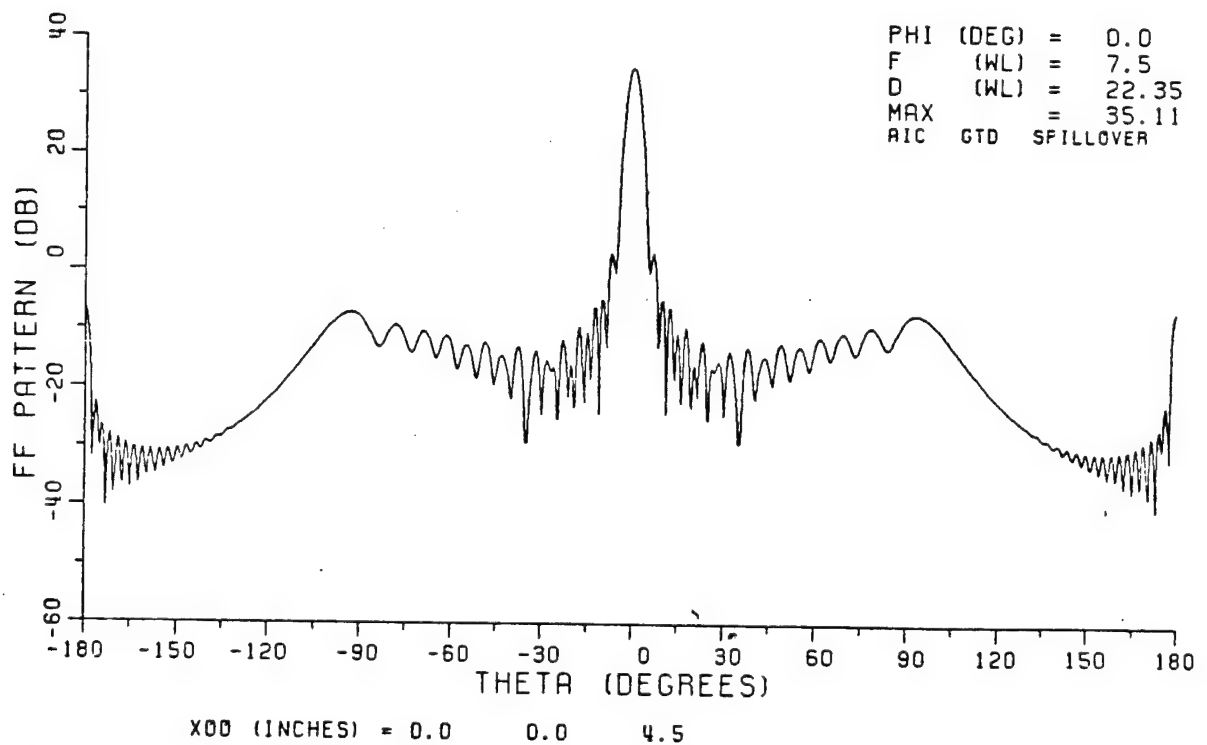


Figure 2. H-plane pattern of the circular reflector antenna calculated by OSU Reflector Antenna Code with default analytic feed.

LINE PRINTER OUTPUT OF EXAMPLE 1

***** OUTPUT LISTING FROM THE OSU REFLECTOR ANTENNA CODE (NASL4) *****

DEFAULT DATA

NTYPE= 1

LINEAR DIMENSION INPUTS ARE IN INCHES

CIRCULAR REFLECTOR WITH APERTURE DIAMETER = 24.00

FOCAL DISTANCE= 8.00 GRIDX= 0.600 GRIDY = 0.600

FEED PATTERN SYMMETRY GIVEN BY: ISYM= 1

LINEARLY POLARIZED FEED

POLARIZED ANGLE = 90.00

ANALYTIC FEED DATA

NPW = 1

N	PHIN(N)	PSIO(N)	AEX(N)	CAN(N)
1	0.0	120.0	5.0	0.09
2	90.0	140.0	6.0	0.10

XQ:

FREQUENCY - 11.000 GHZ

WAVELENGTH = 0.027273 METERS

* THE FOLLOWING DIMENSION UNITS ARE IN WAVELENGTHS *
* ANGLES & PHASE ARE IN DEGREES *

APERTURE DIAMETER = 22.35 WAVELENGTHS

NUMBER OF RIM SEGMENTS- 96

FOCAL DISTANCE = 7.45

GRIDX = 0.56 GRIDY = 0.56

RGEOM:RHOS1,BOUND= 11.73480 13.42983

TABLE 1 - CONTINUED

```

*
* ZOP= 4.191000
*
* DISTANCE FROM FOCUS TO RIM: RO= 11.642
*
* FEED LOCATED AT ( 0.00, 0.00, 7.45,)
* ( REFERRED TO VERTEX )
*
* FEED POWER: PRAD = 0.138E+01
*
* FAR FIELD GAIN REF = -7.859
*
* NUMBER OF PRINCIPAL GRID LINES: MMAX= 43 NMAX= 43
*
* APERTURE CENTER AT ( 0.000, 0.000, 4.191 )
*
*
* CPU TIME FOR APERTURE FIELD CALCULATION = 10.02 SECONDS
*
* SHADOW BOUNDARY ANGLES: TH1 = 253.73 TH2 = 106.27
* THEB (DEG) = 90.000
* NUMBER OF ROTATED GRID LINES: IMAX= 41 JMAX= 41
*
* NP= 1 P2= 0.00
* CPU TIME FOR Y-INTEGRATION = 3.19 SECONDS
*
* AI/GTD SWITCHOVER PARAMETERS:
* THETAX = 12.21 ZX = 0.000
* NT = 73 P3X = 10.000
* NGTD1= 34 PG1I= -180.000
* NAI = 5 PAI = -10.000
* NGTD2= 34 PG2I= 15.000
*
* PHI = 0.00
*
*
* PRINCIPAL POL CROSS POL
*
* THETA MAG DB PHASE MAG DB PHASE
*
W -180.00 0.113E+01 -6.77 130.2 0.108E-05 -127.16 154.4 W
W -175.00 0.746E-01 -30.40 121.9 0.278E-05 -118.97 -5.5 W
W -170.00 0.438E-01 -35.03 100.3 0.873E-06 -129.04 6.5 W
W -165.00 0.338E-01 -37.27 58.4 0.416E-06 -135.49 30.0 W
W -160.00 0.443E-01 -34.94 11.5 0.275E-06 -139.08 69.8 W
W -155.00 0.643E-01 -31.70 -21.1 0.241E-06 -140.22 108.4 W
W -150.00 0.724E-01 -30.67 -55.6 0.223E-06 -140.91 138.3 W
W -145.00 0.653E-01 -31.56 -119.6 0.881E-07 -148.96 -172.3 W
W -140.00 0.845E-01 -29.33 155.2 0.136E-06 -145.19 -59.2 W
W -135.00 0.928E-01 -28.51 57.7 0.603E-07 -152.25 13.8 W
W -130.00 0.116E+00 -26.56 -63.5 0.109E-06 -147.09 144.0 W
W -125.00 0.145E+00 -24.60 152.9 0.343E-07 -157.14 -20.0 W
W -120.00 0.192E+00 -22.20 -13.5 0.306E-07 -158.14 177.4 W
W -115.00 0.266E+00 -19.37 157.0 0.207E-07 -161.55 0.6 W
W -110.00 0.384E+00 -16.17 -54.7 0.146E-07 -164.54 -110.3 W
W -105.00 0.565E+00 -12.81 73.0 0.353E-07 -156.90 62.2 W
W -100.00 0.819E+00 -9.59 -179.2 0.651E-07 -151.59 -137.3 W
W -95.00 0.104E+01 -7.55 -87.7 0.128E-06 -145.73 -66.1 W

```

TABLE 1 - CONTINUED

W	-90.00	0.972E+00	-8.10	-6.1	0.117E-06	-146.49	-0.3	W
W	-85.00	0.629E+00	-11.89	93.9	0.338E-07	-157.27	43.4	W
W	-80.00	0.872E+00	-9.05	-147.0	0.154E-06	-144.11	-131.7	W
W	-75.00	0.740E+00	-10.47	-68.1	0.132E-06	-145.44	-126.9	W
W	-70.00	0.894E+00	-8.83	46.6	0.173E-06	-143.08	55.4	W
W	-65.00	0.662E+00	-11.44	137.0	0.167E-07	-163.43	-72.3	W
W	-60.00	0.817E+00	-9.62	-140.6	0.128E-06	-145.68	-171.0	W
W	-55.00	0.873E+00	-9.04	-45.5	0.154E-06	-144.13	-38.1	W
W	-50.00	0.846E+00	-9.32	41.0	0.166E-06	-143.46	71.8	W
W	-45.00	0.710E+00	-10.84	124.6	0.208E-06	-141.52	-149.7	W
W	-40.00	0.657E+00	-11.51	-179.3	0.101E-06	-147.81	-28.6	W
W	-35.00	0.524E+00	-13.46	-110.9	0.237E-06	-140.35	43.9	W
W	-30.00	0.654E+00	-11.55	-58.2	0.166E-06	-143.47	99.8	W
W	-25.00	0.594E+00	-12.38	-29.3	0.269E-06	-139.27	-176.2	W
W	-20.00	0.299E+00	-18.36	-1.6	0.500E-06	-133.88	-157.1	W
W	-15.00	0.178E+00	-22.84	162.3	0.853E-06	-129.24	-138.8	W
W	-10.00	0.974E+00	-8.08	-171.4	0.111E-05	-126.99	139.0	W
W	-5.00	0.398E+01	4.14	47.7	0.153E-05	-124.19	107.3	W
W	0.00	0.138E+03	34.96	39.0	0.112E-04	-106.87	39.0	W
W	5.00	0.398E+01	4.14	47.7	0.144E-05	-124.69	-28.1	W
W	10.00	0.974E+00	-8.08	-171.4	0.103E-05	-127.60	-61.7	W
W	15.00	0.178E+00	-22.84	162.3	0.280E-06	-138.91	39.9	W
W	20.00	0.299E+00	-18.36	-1.6	0.141E-06	-144.87	28.9	W
W	25.00	0.594E+00	-12.38	-29.3	0.138E-06	-145.05	-12.1	W
W	30.00	0.654E+00	-11.55	-58.2	0.994E-07	-147.91	-71.5	W
W	35.00	0.524E+00	-13.47	-110.9	0.126E-06	-145.84	-126.9	W
W	40.00	0.657E+00	-11.51	-179.3	0.104E-06	-147.51	173.5	W
W	45.00	0.710E+00	-10.84	124.6	0.122E-06	-146.15	68.8	W
W	50.00	0.846E+00	-9.32	41.0	0.567E-07	-152.78	-18.5	W
W	55.00	0.873E+00	-9.04	-45.5	0.378E-07	-156.30	-68.7	W
W	60.00	0.817E+00	-9.62	-140.6	0.380E-07	-156.27	-99.1	W
W	65.00	0.662E+00	-11.44	137.0	0.759E-07	-150.26	134.3	W
W	70.00	0.894E+00	-8.83	46.6	0.139E-07	-165.01	-102.7	W
W	75.00	0.740E+00	-10.47	-68.1	0.102E-06	-147.70	0.7	W
W	80.00	0.872E+00	-9.05	-147.0	0.243E-07	-160.14	106.1	W
W	85.00	0.629E+00	-11.89	93.9	0.648E-07	-151.63	107.7	W
W	90.00	0.972E+00	-8.10	-6.1	0.474E-07	-154.34	-23.1	W
W	95.00	0.104E+01	-7.55	-87.7	0.513E-07	-153.66	-133.8	W
W	100.00	0.819E+00	-9.59	-179.2	0.817E-07	-149.61	138.3	W
W	105.00	0.565E+00	-12.81	73.0	0.217E-07	-161.14	31.2	W
W	110.00	0.384E+00	-16.17	-54.7	0.121E-06	-146.23	-70.6	W
W	115.00	0.266E+00	-19.37	157.0	0.149E-06	-144.41	146.6	W
W	120.00	0.192E+00	-22.20	-13.5	0.140E-06	-144.95	-21.6	W
W	125.00	0.145E+00	-24.60	152.9	0.162E-06	-143.68	146.8	W
W	130.00	0.116E+00	-26.56	-63.5	0.186E-06	-142.47	-62.4	W
W	135.00	0.928E-01	-28.51	57.7	0.128E-06	-145.74	60.3	W
W	140.00	0.845E-01	-29.33	155.2	0.239E-06	-140.30	145.7	W
W	145.00	0.653E-01	-31.56	-119.6	0.187E-06	-142.43	-119.4	W
W	150.00	0.724E-01	-30.67	-55.6	0.322E-06	-137.70	-57.2	W
W	155.00	0.643E-01	-31.70	-21.1	0.348E-06	-137.03	-24.4	W
W	160.00	0.443E-01	-34.94	11.5	0.390E-06	-136.03	13.4	W
W	165.00	0.338E-01	-37.27	58.4	0.517E-06	-133.59	50.9	W
W	170.00	0.438E-01	-35.03	100.3	0.101E-05	-127.78	74.9	W
W	175.00	0.746E-01	-30.40	121.9	0.298E-05	-118.38	90.4	W
W	180.00	0.113E+01	-6.77	130.2	0.174E-05	-123.04	164.0	W

CPU TIME = 22.32 SECONDS

***** OUTPUT LISTING FROM THE OSU REFLECTOR ANTENNA CODE (NASL4) *****

TABLE 1 - CONTINUED

 *
 * EN:
 *

EXAMPLE 2

This example uses the default reflector but with a piecewise linear feed pattern (LLFD=T). The measured feed patterns for this antenna as given in Reference [12] are shown in Figure 3. The feed is linearly polarized in the y-direction. The piecewise linear feed pattern option of the reflector code was used to approximate the measured H- and E-plane feed patterns as shown in Figures 4a and 4b, respectively.

The far field patterns as computed by the reflector code are shown in Figures 5a and b for the H- and E-planes, respectively. The results from the reflector code were found to be in good agreement with the calculated results of Reference [12] without aperture blockage as shown in Figures 6a and b. Full pattern plots for $\phi=0^\circ$, 90° and 45° are shown in Figure 7. The cross polarized component is very low in the principal planes for this case; however, the cross polarization for $\phi=45^\circ$ is shown in Figure 7d. The input data are given in Table 2.

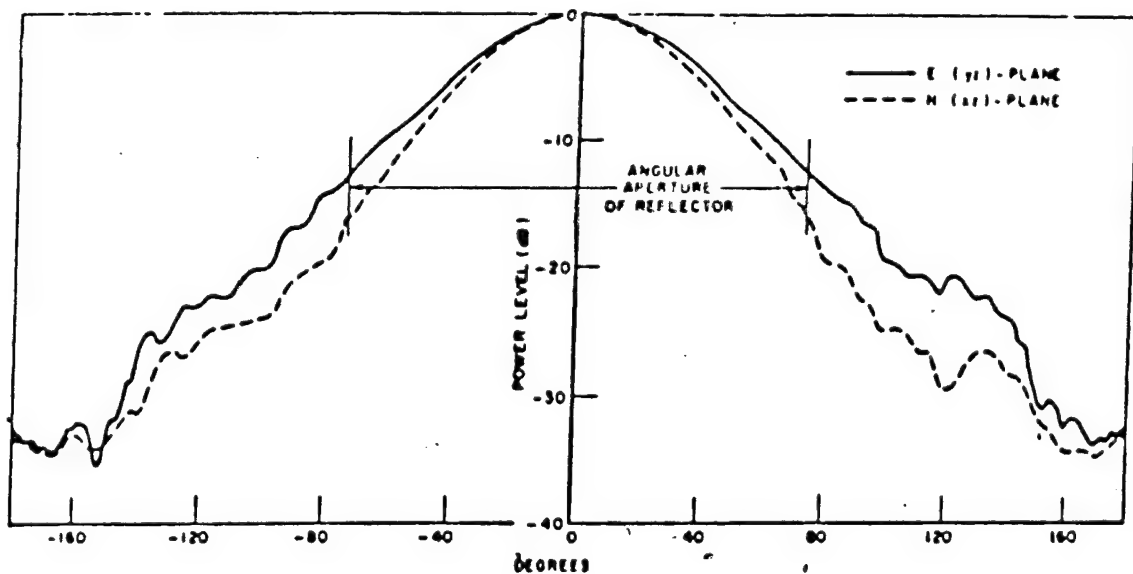
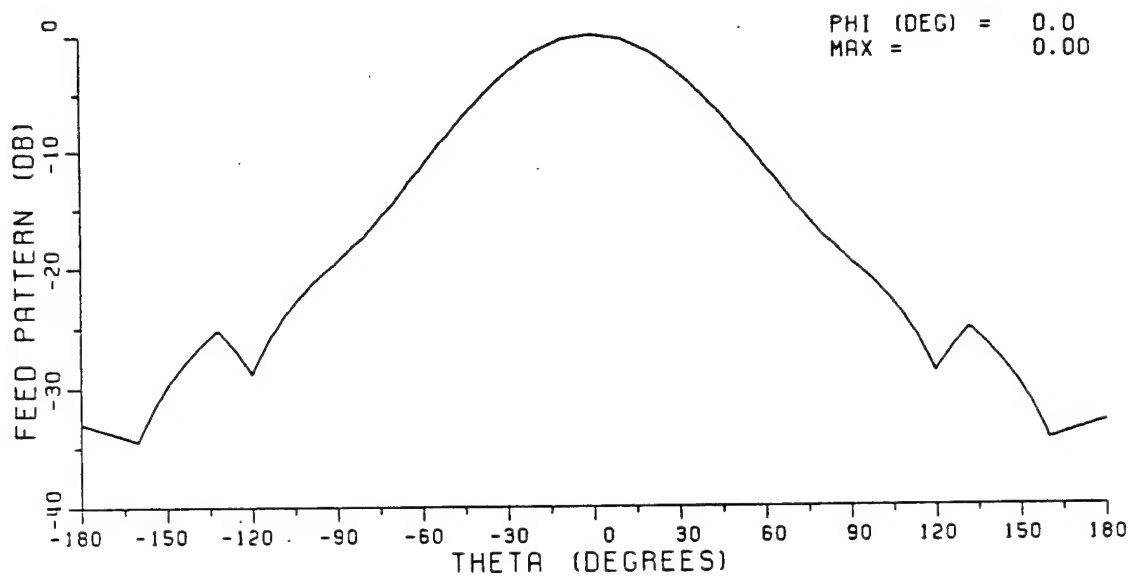
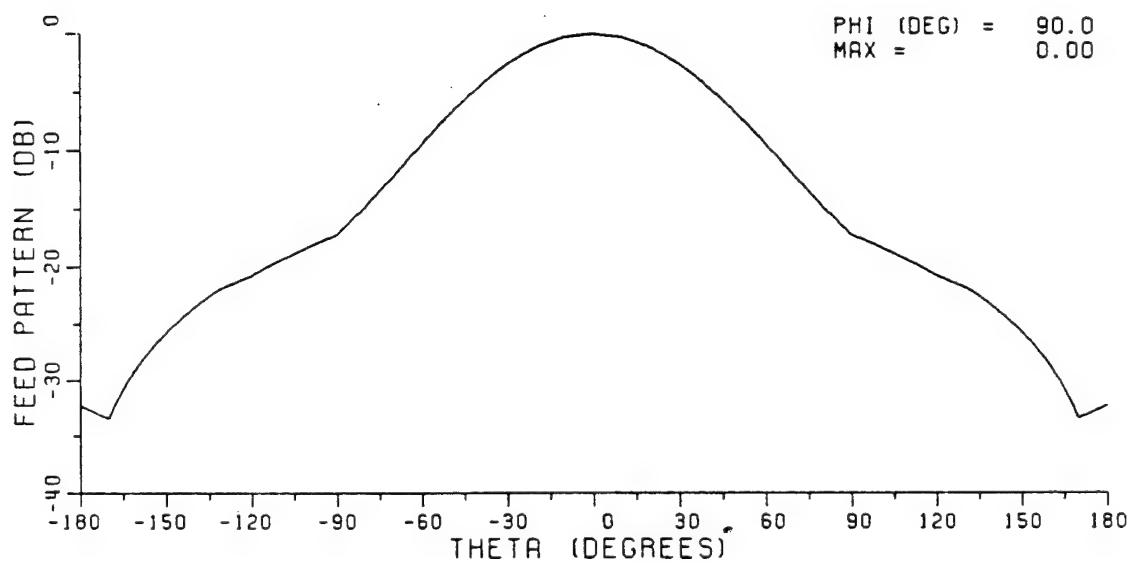


Figure 3. Measured primary field patterns of a flanged waveguide feed.



(a) H-plane



(b) E-plane

Figure 4. Input feed patterns for circular reflector Example 2.

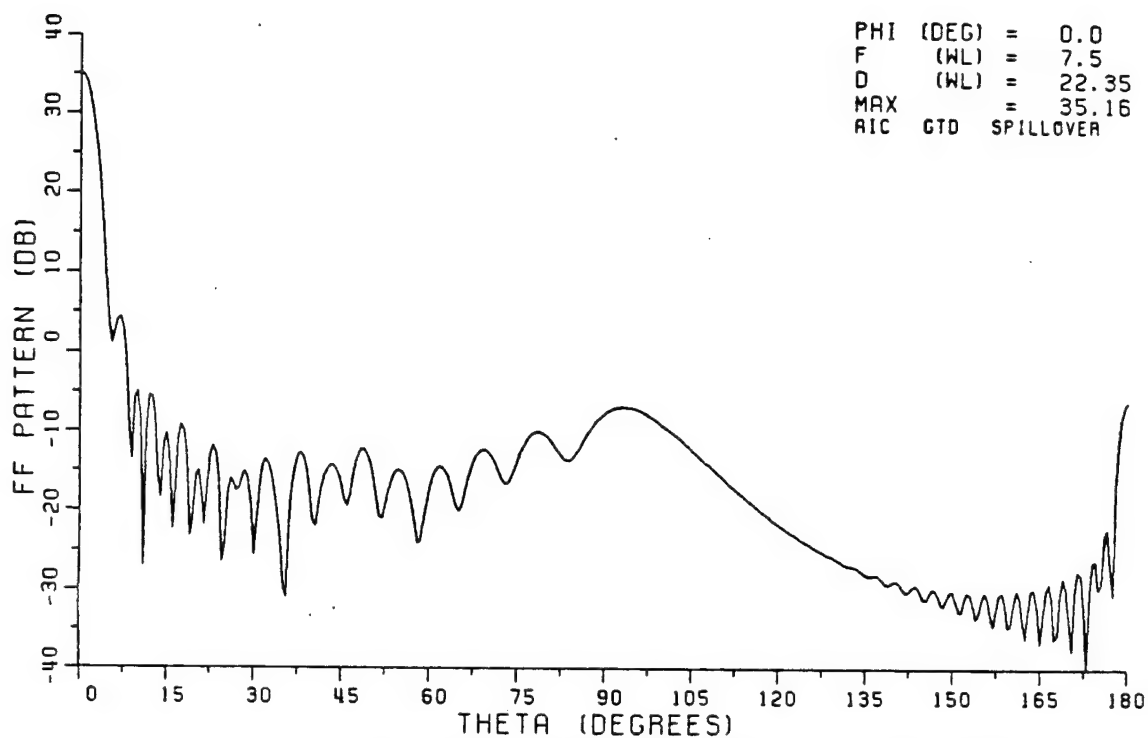


Figure 5a. Far field pattern of Example 2 computed by OSU Reflector Antenna Code. PHI=0.0 degrees.

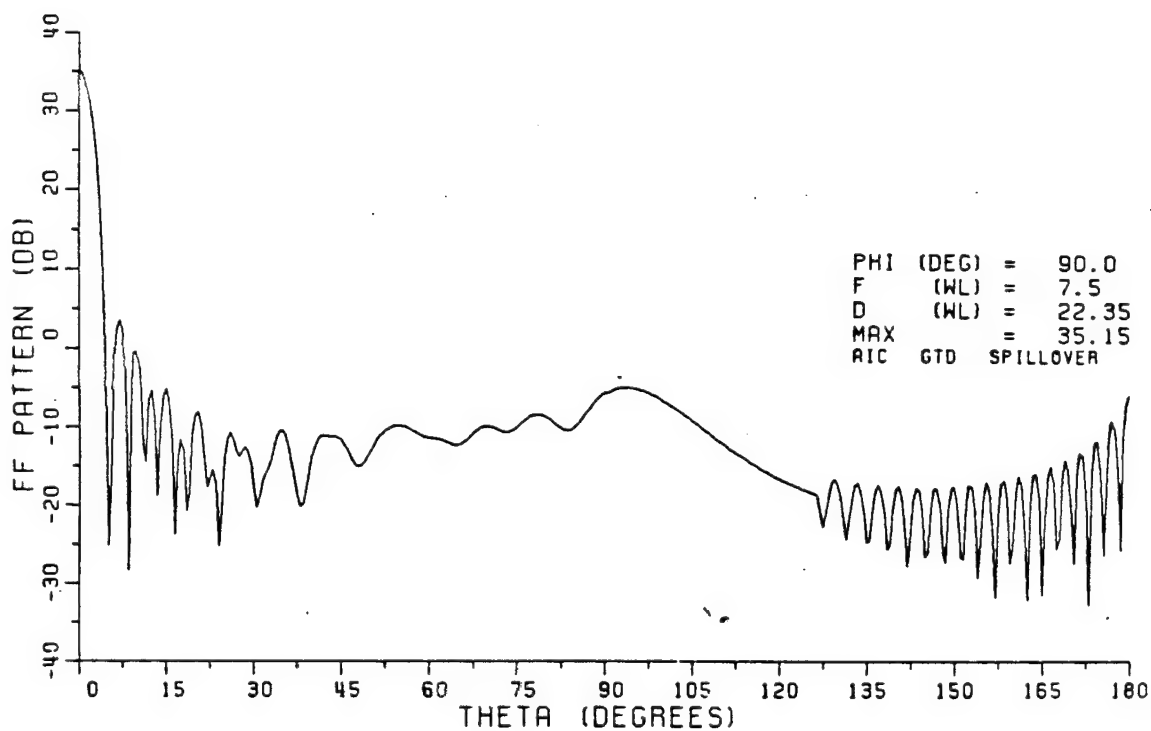


Figure 5b. Far field pattern of Example 2 computed by OSU Reflector Antenna Code. PHI=90.0 degrees.

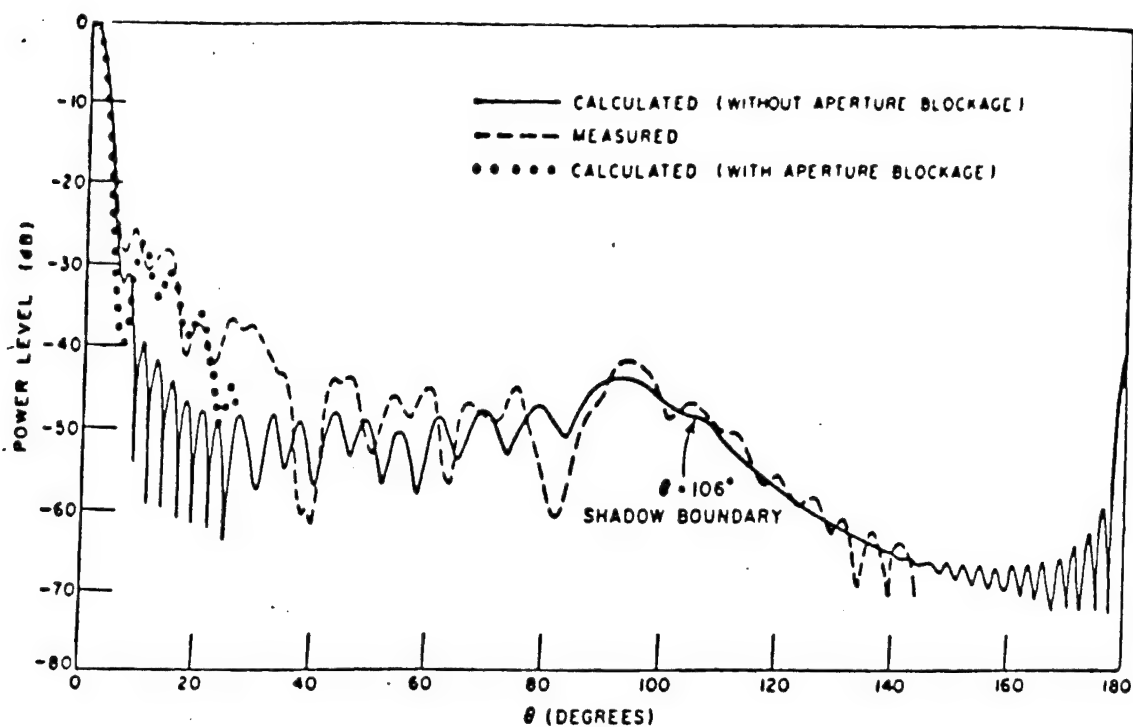


Figure 6a. H-plane pattern of a parabolic reflector with a flanged waveguide feed. Computed in Reference [12].

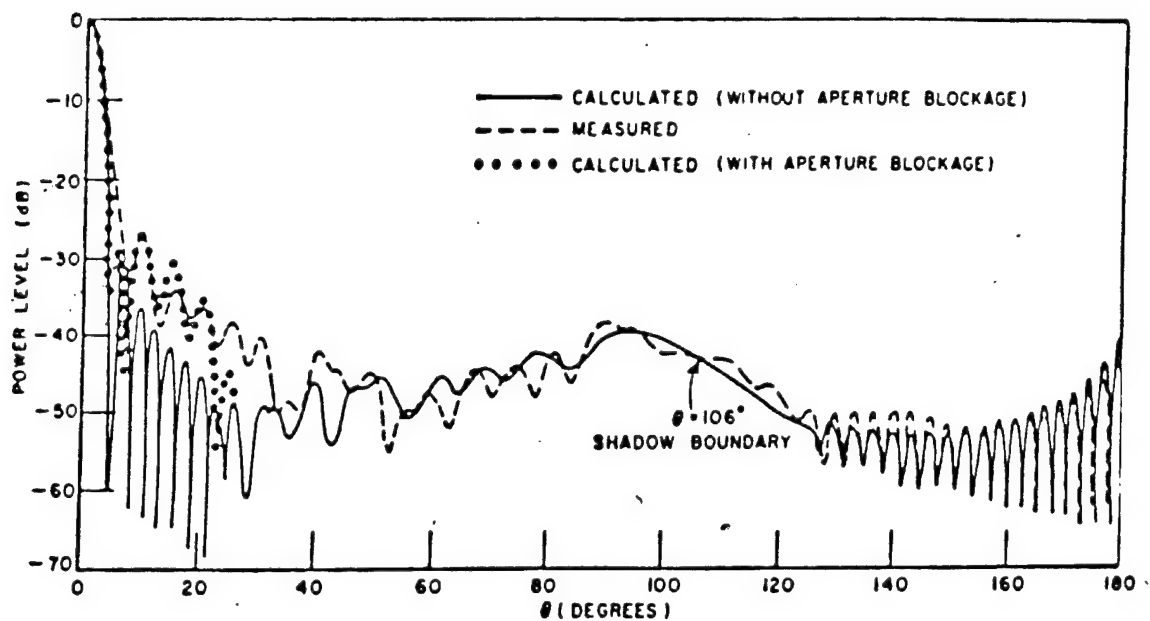


Figure 6b. E-plane pattern of a parabolic reflector with a flanged waveguide feed. Computed in Reference [12].

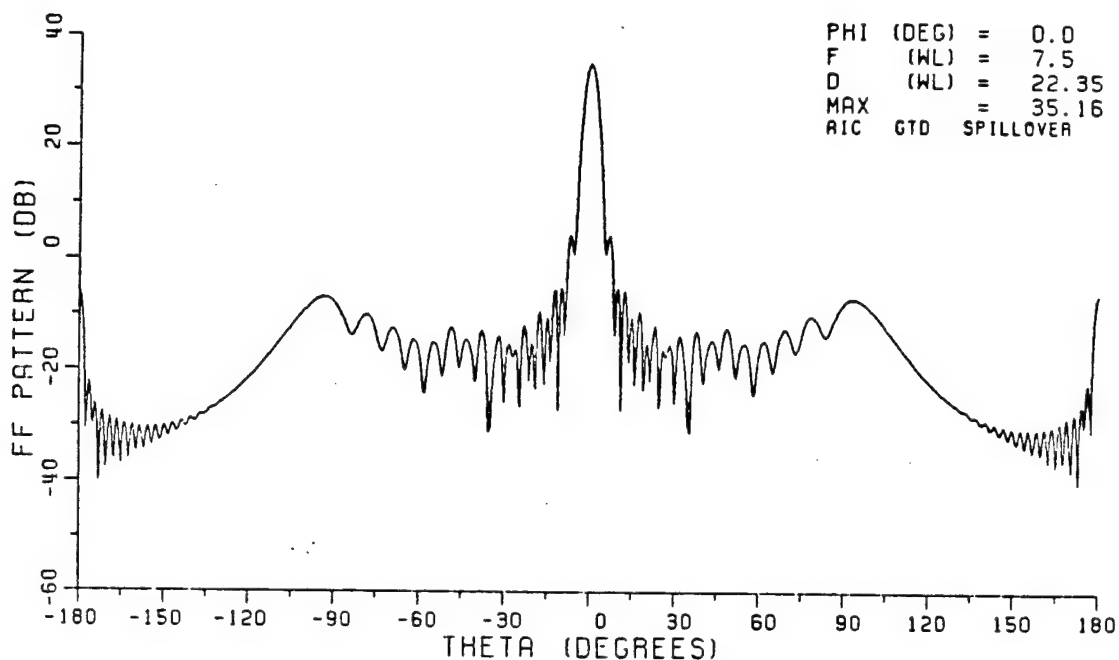


Figure 7a. Full far field pattern of Example 2 computed by OSU Reflector Antenna Code. PHI=0.0 degrees.

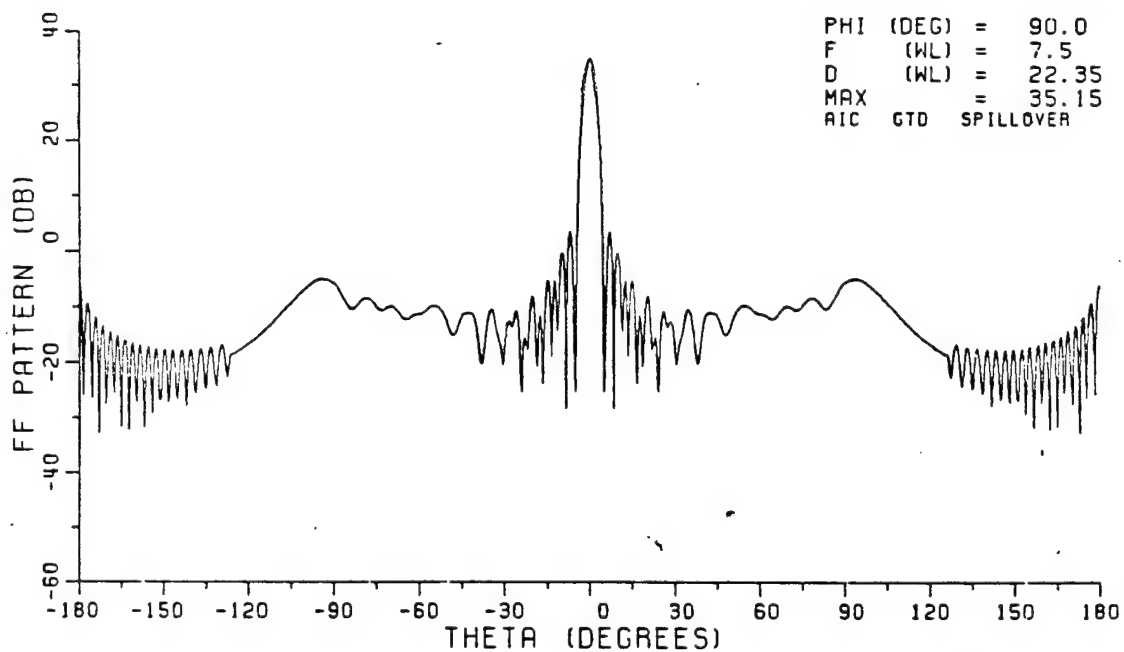


Figure 7b. Full far field pattern of Example 2 computed by OSU Reflector Antenna Code. PHI=90.0 degrees.

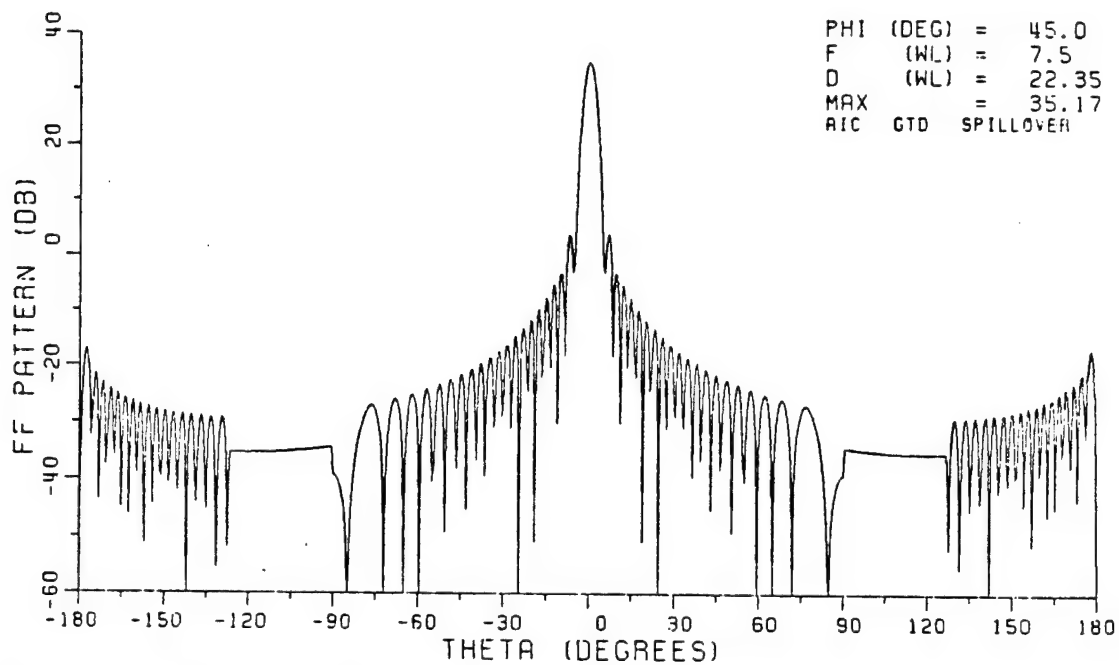


Figure 7c. Full far field pattern of Example 2 computed by OSU Reflector Antenna Code. PHI=45.0 degrees.

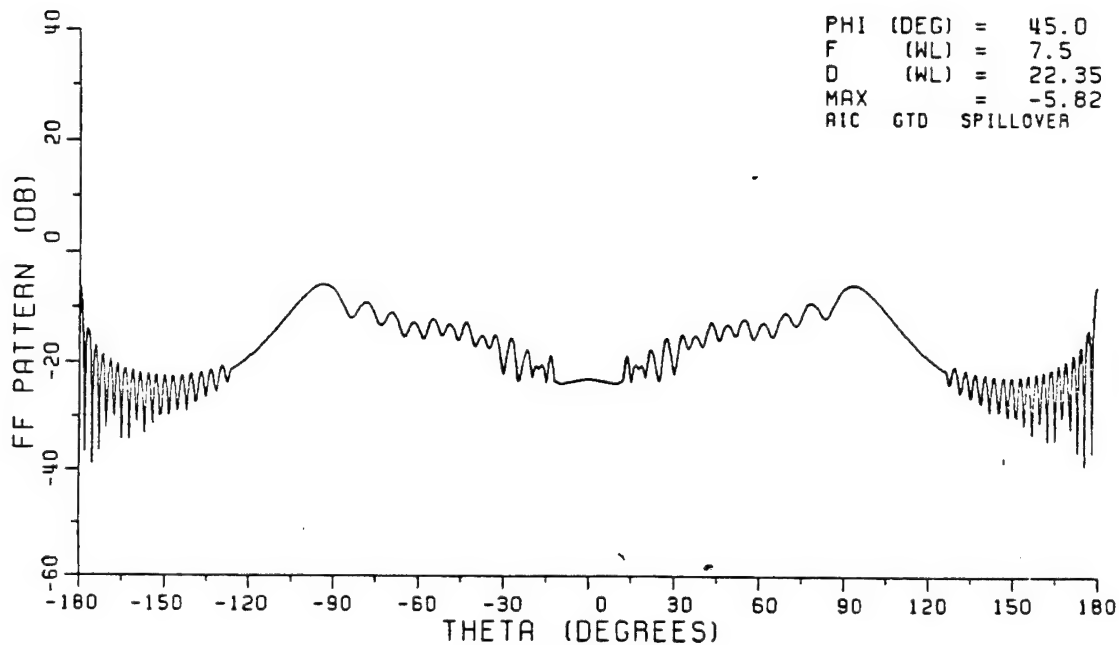


Figure 7d. Cross polarized far field pattern of Example 2 computed by OSU Reflector Antenna Code. PHI=45.0 degrees.

TABLE 2
INPUT DATA FOR CIRCULAR REFLECTOR
EXAMPLE 2

```

CM:          ***** C24B.DAT *****
CM: GENERAL  EXAMPLE OF 24" CIRCULAR REFLECTOR
CE:          LINEAR FEED (LLFD-T)
DG:
1
3  8.  0.6  0.6  24.  0
FD:
0  T
T  0  F  1  90.  0.  F
2  0.  90.
14
0.      1.0000  0.      0.0000  0.
10.     0.9575  0.      0.0000  0.
20.     0.8419  0.      0.0000  0.
30.     0.6840  0.      0.0000  0.
40.     0.5200  0.      0.0000  0.
50.     0.3772  0.      0.0000  0.
60.     0.2664  0.      0.0000  0.
70.     0.1866  0.      0.0000  0.
80.     0.1358  0.      0.0000  0.
90.     0.10521 0.      0.0000  0.
120.    0.03588 0.      0.0000  0.
132.    0.05475 0.      0.0000  0.
160.    0.01884 0.      0.0000  0.
180.    0.02240 0.      0.0000  0.
0.      1.0000  0.      0.0000  0.
10.     0.9660  0.      0.0000  0.
20.     0.8714  0.      0.0000  0.
30.     0.7375  0.      0.0000  0.
40.     0.5900  0.      0.0000  0.
50.     0.4522  0.      0.0000  0.
60.     0.3360  0.      0.0000  0.
70.     0.2456  0.      0.0000  0.
80.     0.1813  0.      0.0000  0.
90.     0.13778 0.      0.0000  0.
120.    0.09170 0.      0.0000  0.
132.    0.07900 0.      0.0000  0.
170.    0.02114 0.      0.0000  0.
180.    0.02427 0.      0.0000  0.
PZ:
3
0.  45.  90.
-180. 180.  0.5
F
PF:
1
1  2
1  2
2  2
PF:
2
0.  90.
-180. 180.  1.
1
2
XQ:

```


EXAMPLE 3

This example illustrates the effects of the feed blockage and strut scattering. The antenna and feed pattern are the same as that in Example 2 except that the scattering from the feed blockage and struts as shown in Figure 1 are added in this example. Three different ϕ cuts at 0° , -15° and 90° are calculated and the results are shown in Figure 8. Also, the individual contributions from feed blockage and strut scattering for the $\phi=90^\circ$ cut are shown in Figures 9a and b, respectively. Note that the strut scattering has a large effect in the $\phi=90^\circ$ pattern cut because one of the struts is located at 90° in this case. Also note that the value of the strut boundary angle θ_{ST} is set to 100° ; this causes a discontinuity at $\theta=100^\circ$ in the 90° cut as seen in Figures 8 and 9. The input data for this case are given in Table 3.

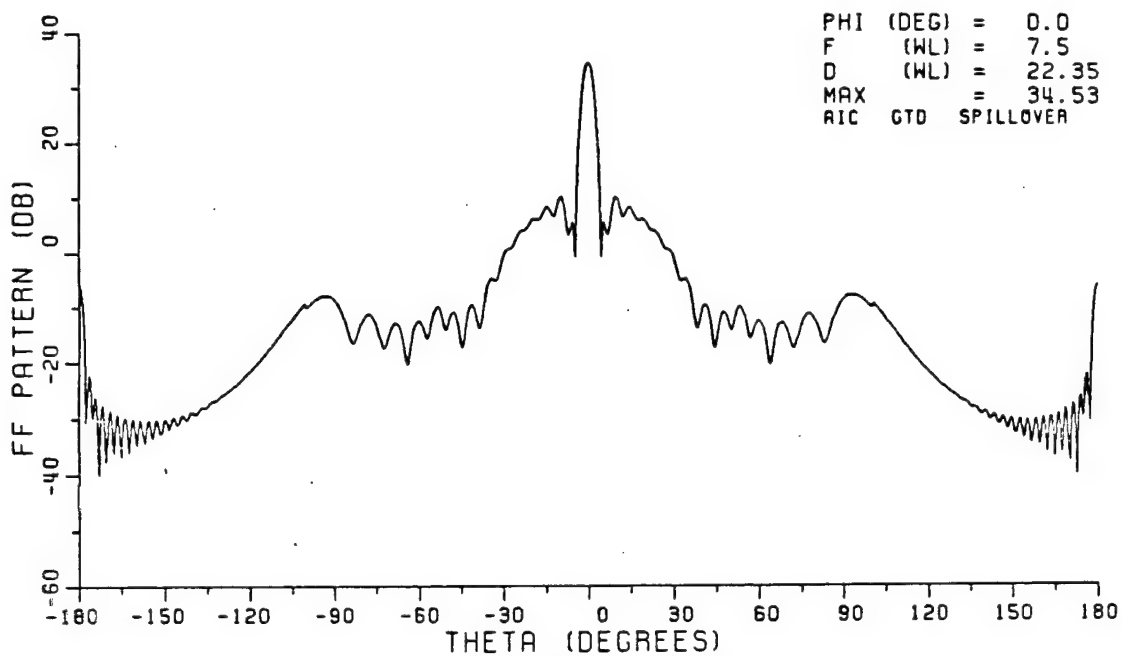


Figure 8a. Far field pattern of Example 3 computed by OSU Reflector Antenna Code. PHI=0.0 degrees.

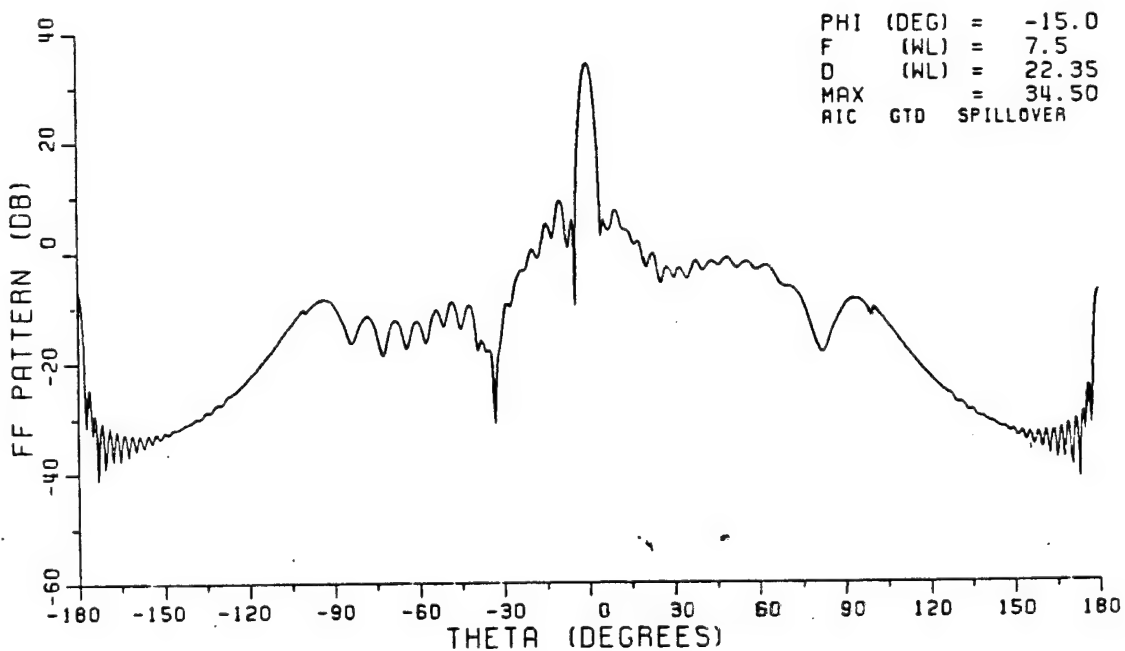


Figure 8b. Far field pattern of Example 3 computed by OSU Reflector Antenna Code. PHI=-15.0 degrees.

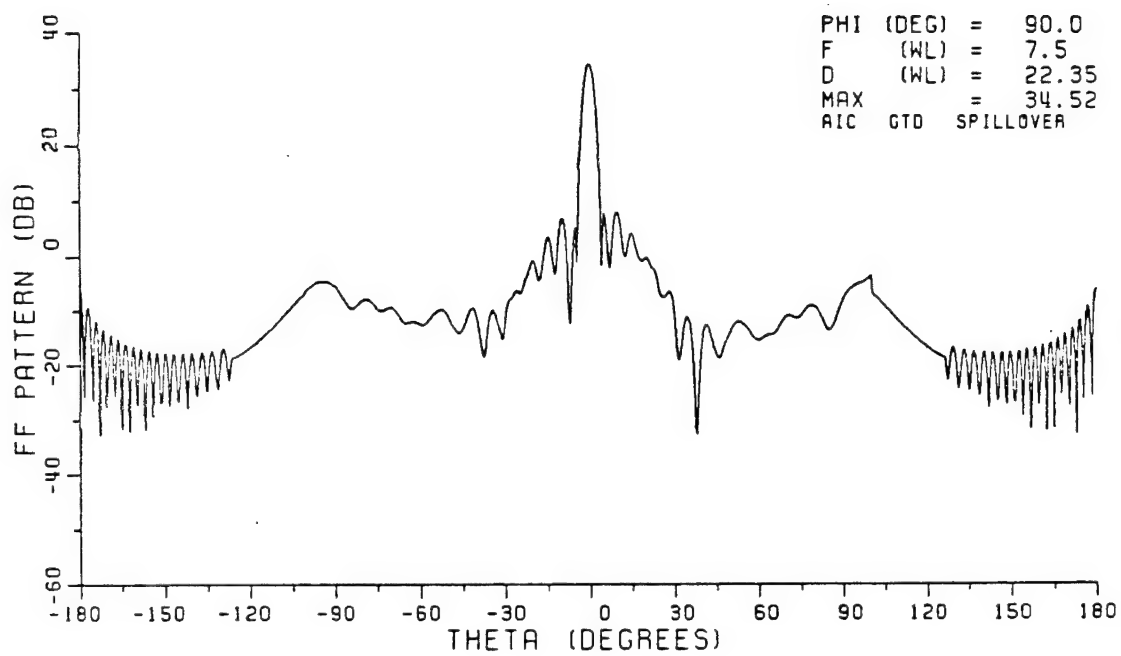


Figure 8c. Far field pattern of Example 3 computed by OSU Reflector Antenna Code. PHI=90.0 degrees.

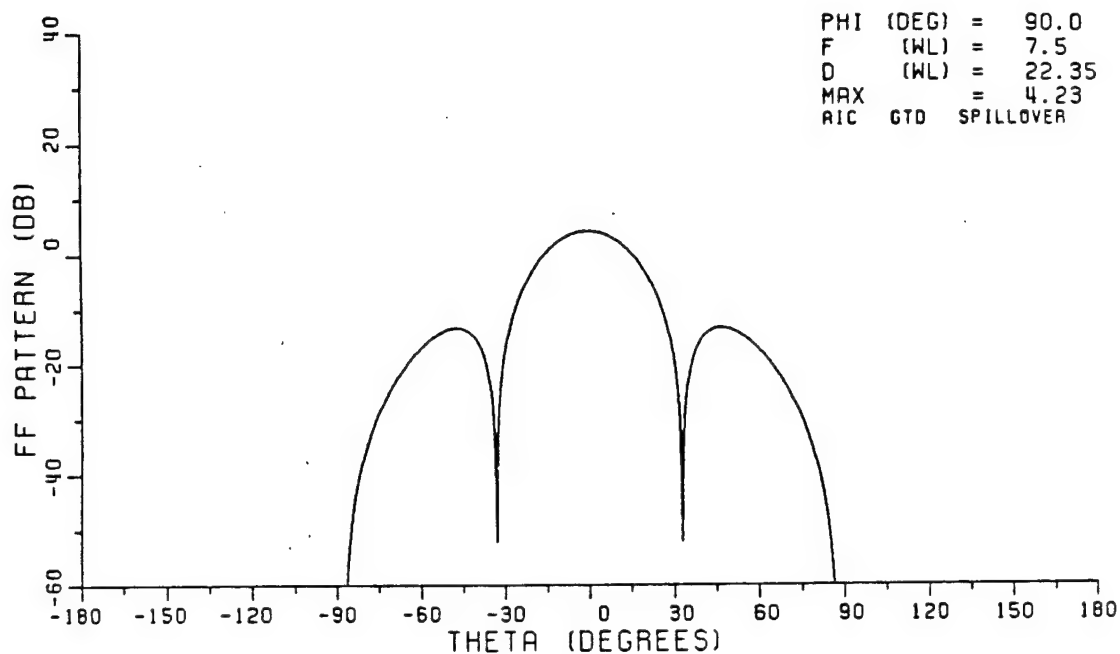


Figure 9a. Feed blockage contribution of Example 3 for PHI=90.0 degrees.

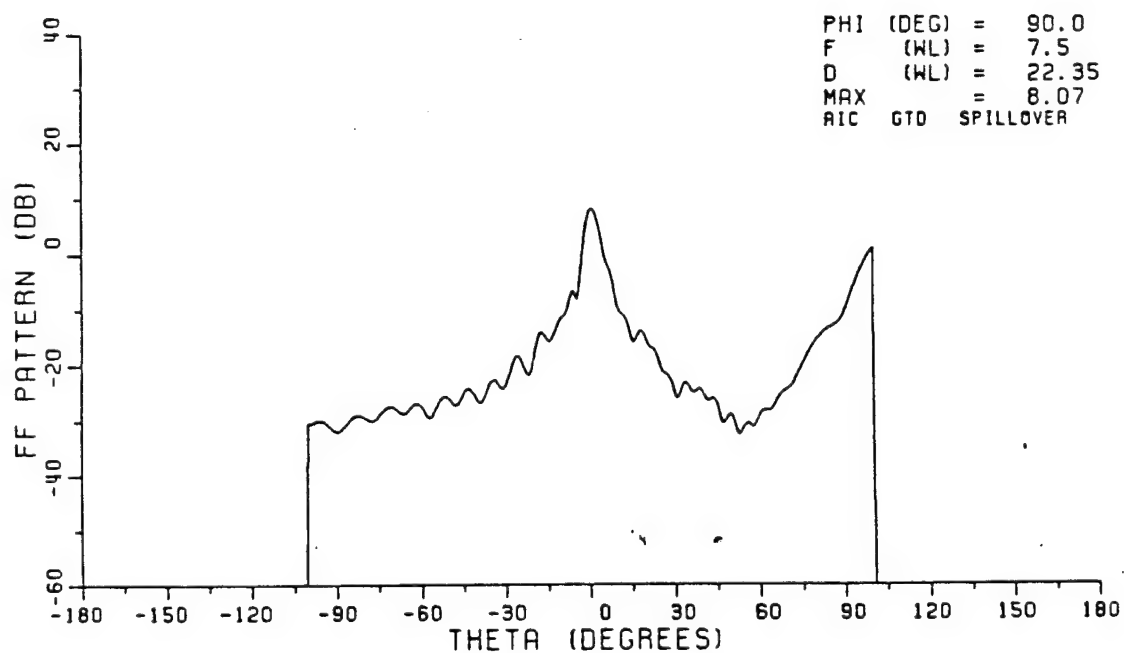


Figure 9b. Strut scattering contribution of Example 3 for PHI=90.0 degrees.

TABLE 3
INPUT DATA FOR THE CIRCULAR REFLECTOR
EXAMPLE 3

CM: ***** C24ST.DAT *****
CM: GENERAL EXAMPLE OF 24" CIRCULAR REFLECTOR
CM: WITH STRUT, FEED BLOCKAGE
CE: 3 CIRCULAR STRUTS, 2.4" DIAMETER FEED BLOCKAGE
FD:

0 T
T 0 F 1 90. 0. F
2 0. 90.
14
0. 1.0000 0. 0.0000 0.
10. 0.9575 0. 0.0000 0.
20. 0.8419 0. 0.0000 0.
30. 0.6840 0. 0.0000 0.
40. 0.5200 0. 0.0000 0.
50. 0.3772 0. 0.0000 0.
60. 0.2664 0. 0.0000 0.
70. 0.1866 0. 0.0000 0.
80. 0.1358 0. 0.0000 0.
90. 0.10521 0. 0.0000 0.
120. 0.03588 0. 0.0000 0.
132. 0.05475 0. 0.0000 0.
160. 0.01884 0. 0.0000 0.
180. 0.02240 0. 0.0000 0.
0. 1.0000 0. 0.0000 0.
10. 0.9660 0. 0.0000 0.
20. 0.8714 0. 0.0000 0.
30. 0.7375 0. 0.0000 0.
40. 0.5900 0. 0.0000 0.
50. 0.4522 0. 0.0000 0.
60. 0.3360 0. 0.0000 0.
70. 0.2456 0. 0.0000 0.
80. 0.1813 0. 0.0000 0.
90. 0.13778 0. 0.0000 0.
120. 0.09170 0. 0.0000 0.
132. 0.07900 0. 0.0000 0.
170. 0.02114 0. 0.0000 0.
180. 0.02427 0. 0.0000 0.

FB:
1 0. 0. 8.

2.4

ST: THEST=100.

1
3 0.5 100. F T T T
10.8 90. 3.65
0.0 0. 8.00
3
0.37
10.8 210. 3.65
0.0 0. 8.00
10.8 330. 3.65
0.0 0. 8.00

PZ:

3
-15. 0. 90.
-180. 180. 0.5

F

FP:

3

1 1

1 2

3 1

1 2

4 1

1 2

XQ:

! TOTAL

! FEED BLOCKAGE

! REFLECTOR/STRUT

EXAMPLE 4

Example 4 uses the circular reflector and analytic feed of Example 1 except that near field results are calculated instead of far field patterns. In this example, three constant range cases with $R=40\lambda$, $R=100\lambda$, and $R=1000\lambda$, are shown in Figures 10a, b, and c, respectively.

For this $D=22.35\lambda$ circular reflector, $2D^2/\lambda=999\lambda$, so for the $R=1000\lambda$ case, it is in the far field range. This can be verified by comparing the results in Figures 7a and 10c. The input data are given in Table 4.

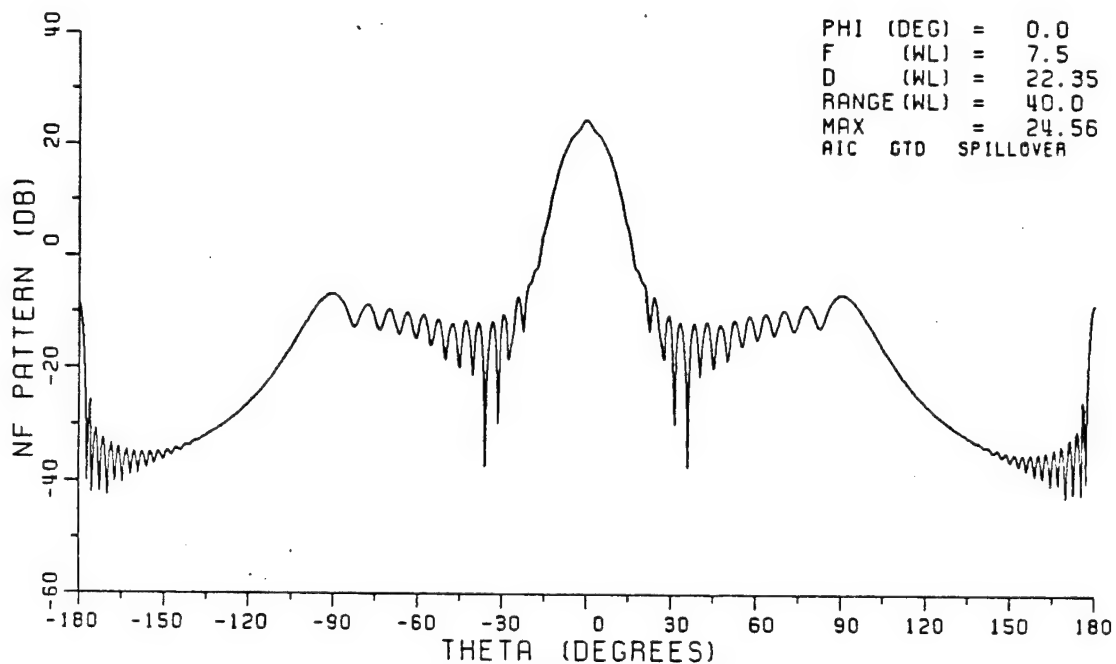


Figure 10a. Near field pattern of Example 4 computed by OSU Reflector Antenna Code. PHI=0.0 degrees, RANGE = 40.0 wavelengths.

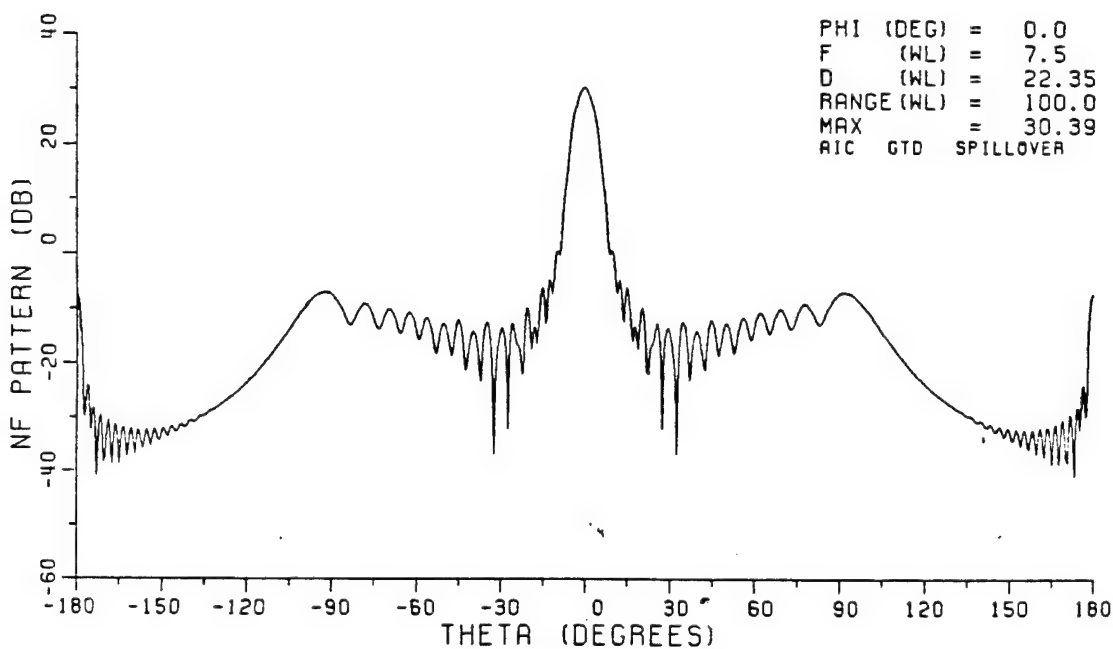


Figure 10b. Near field pattern of Example 4 computed by OSU Reflector Antenna Code. PHI=0.0 degrees, RANGE = 100.0 wavelengths.

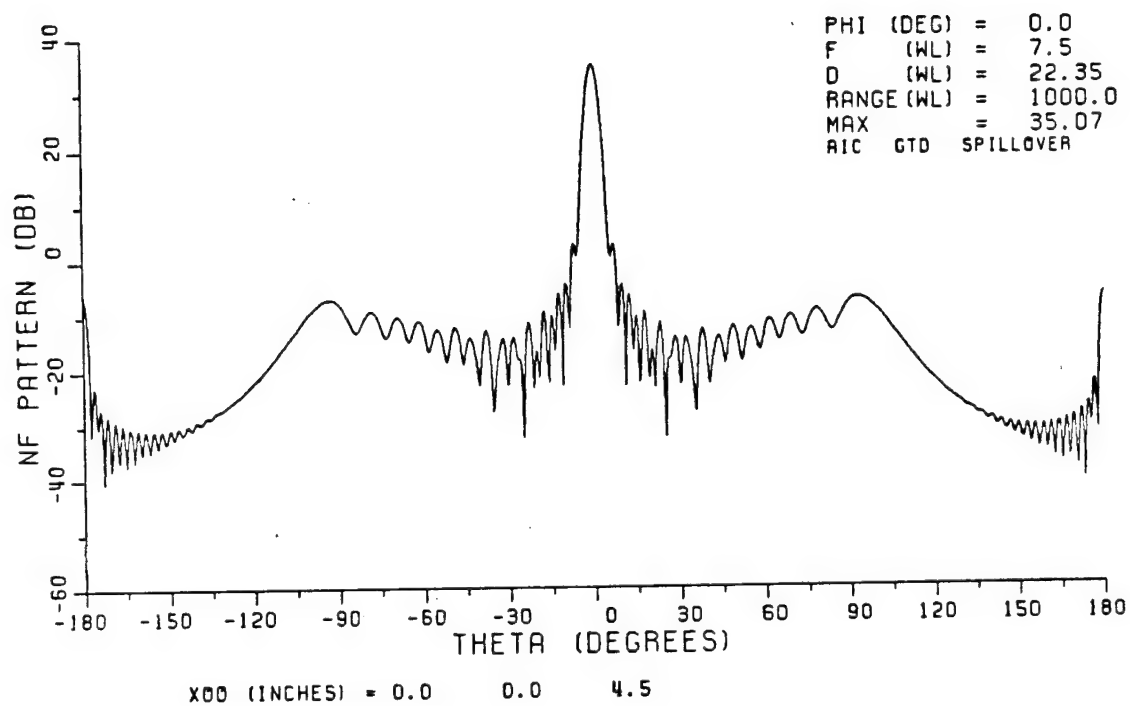


Figure 10c. Near field pattern of Example 4 computed by OSU Reflector Antenna Code. PHI=0.0 degrees, RANGE = 1000.0 wavelengths.

TABLE 4
INPUT DATA FOR THE CIRCULAR REFLECTOR
EXAMPLE 4

```

CM:          ***** C24N.DAT *****
CM: GENERAL EXAMPLE OF 24" CIRCULAR REFLECTOR
CE:          NEAR FIELD
NF:
0.    0.    4.5
T
T
0.
PZ:
3
42.9497 107.3742 1073.742
-180.    180.    0.5
F
PP:
1
1  1
1  2
XQ:

```

APPENDIX C

EXAMPLES OF OFFSET REFLECTOR ANTENNAS

In this section, two offset reflector antennas are used as examples to illustrate how the offset can be achieved by the TL: command. The first example is for an offset circular reflector and the second example is for an offset square reflector antenna.

EXAMPLE 1

Example 1 is an off-set fed reflector system with a corrugated horn feed designed at NRL [13]. The geometry of the antenna is shown in Figure 1. Two different methods to input the feed information are demonstrated in this example. The first method uses the piecewise linear feed pattern input which was read from the envelope of the measured horn pattern shown in Figure 2.

The second method inputs the feed horn geometry and uses the feedhorn source model to generate the feed patterns in the reflector code. This model eliminates the need to input the feed pattern data point by point. Input is accomplished by specifying the flare angles. The E-plane far field pattern calculated by these two methods are shown in Figure 3 and 4. Note that there is some difference in these two patterns because the first one uses a constant phase feed pattern but the feedhorn model has the phase included. This example also shows the use of the TL: Command for a feed axis tilt. The input data for the first method are given in Table 1 and the input data for the second method are given in Table 2.

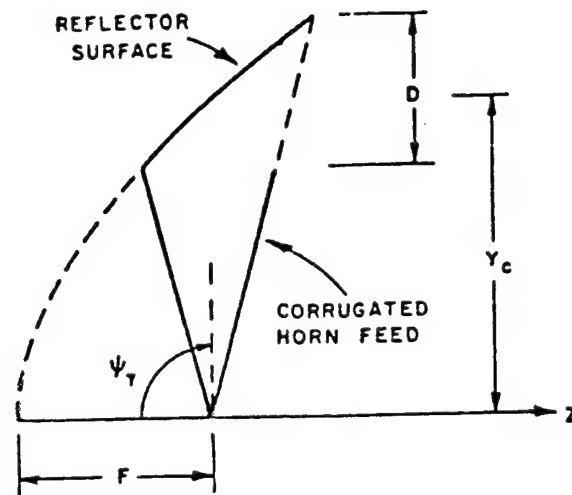


Figure 1. Geometry of an off-set fed reflector antenna with $D=35.2$ cm, $F=32.83$ cm, $Y_c=65.66$ cm, $\psi_T=90^\circ$.

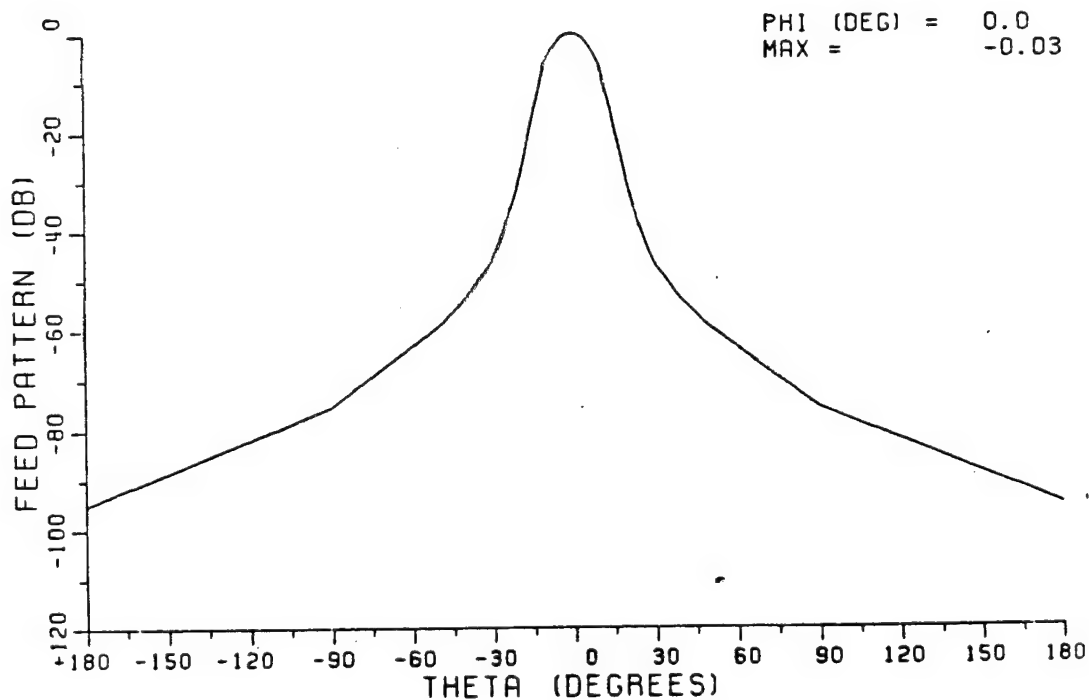


Figure 2. Input feed pattern for offset circular reflector of Figure 1.

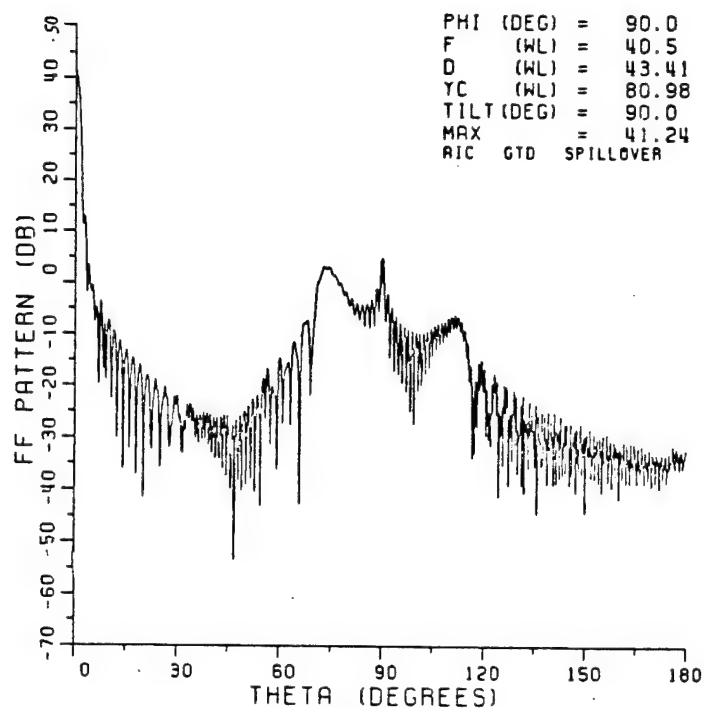


Figure 3. Far field pattern of Example 1 using the piecewise linear feed pattern input. PHI=90.0 degrees.

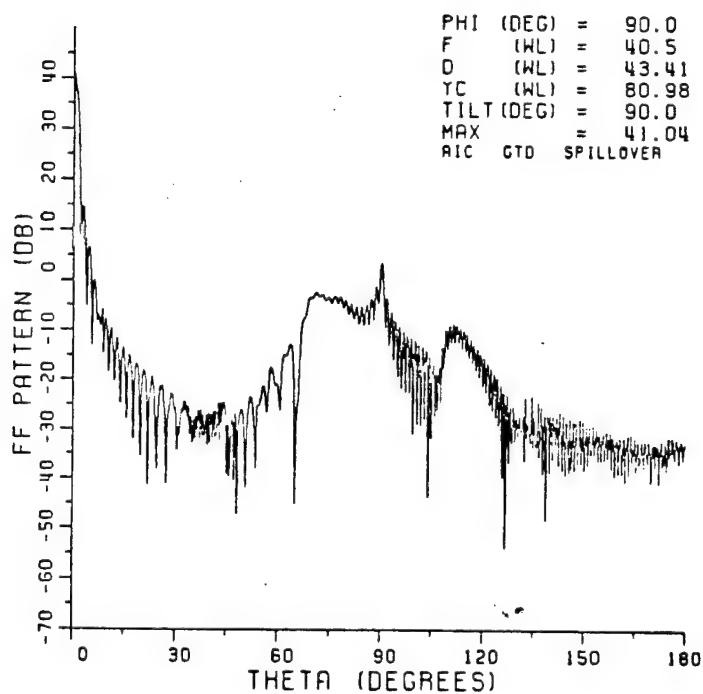


Figure 4. Far field pattern of Example 1 using horn feed geometry inputs. PHI=90.0 degrees.

TABLE 1

INPUT DATA FOR THE OFFSET CIRCULAR REFLECTOR
WITH PIECEWISE LINEAR FEED INPUT

```

CM:      ***** NRL.DAT *****
CM: EXAMPLE OF OFFSET CIRCULAR REFLECTOR
CE:      LINEAR FEED INPUT
DG:
1
1 0.3281 0.015 0.015 0.352 0
TL:
90. 0.6566
FD:
0 T
T 0 T 1 90. 0. F
2 0. 90.
1Z
0. -0.03 0. -300.0 0.
2. -0.10 0. -300.0 0.
5. -1.20 0. -300.0 0.
10. -6.12 0. -300.0 0.
15. -17.60 0. -300.0 0.
20. -30.10 0. -300.0 0.
25. -39.60 0. -300.0 0.
30. -46.70 0. -300.0 0.
40. -54.00 0. -300.0 0.
50. -59.40 0. -300.0 0.
90. -75.50 0. -300.0 0.
180. -95.00 0. -300.0 0.
0. -0.03 0. -300.0 0.
2. -0.10 0. -300.0 0.
5. -1.20 0. -300.0 0.
10. -6.12 0. -300.0 0.
15. -17.60 0. -300.0 0.
20. -30.10 0. -300.0 0.
25. -39.60 0. -300.0 0.
30. -46.70 0. -300.0 0.
40. -54.00 0. -300.0 0.
50. -59.40 0. -300.0 0.
90. -75.50 0. -300.0 0.
180. -95.00 0. -300.0 0.
FQ:
1 37.
PZ:
1
90.
0. 180. 0.2
F
PP:
1
1 1
1 2
PF:
1
0.
-180. 180. 2.
1
2
XQ:

```

TABLE 2

INPUT DATA FOR THE OFFSET CIRCULAR REFLECTOR WITH FEED HORN GEOMETRY INPUT

```

CM:          ***** NRH.DAT *****
CM: EXAMPLE OF OFFSET CIRCULAR REFLECTOR
CE:          FEED HORN GEOMETRY INPUT
DG:
1
1  0.3281  0.015  0.015  0.352  0
TL:
90.  0.6566
FD:
2  T
F
30.  0.254  30.  0.254  0.476  90.  F
FQ:
1  37.
PZ:
1
90.
0.  180.  0.2
F
PP:
1
1  1
1  2
XQ:

```

EXAMPLE 2

Example 2 uses the measured data published in Reference [14] for a square offset reflector antenna. The offset reflector with a 50.8 cm square aperture and a corrugated horn feed is shown in Figure 5. The measured feed patterns [14] are shown in Figure 6 for 20.6 GHz, and the linear feed input which was obtained by extrapolating the measured pattern is shown in Figure 7. The far field patterns calculated from the reflector code are shown in Figure 8 and are in excellent agreement with the published far field patterns shown in Figure 9. The published near field measurements are shown in Figure 10 for the two principal plane cut ($\phi=0^\circ$ and 90°) in the constant Z plane at $Z=1.07$ m. The near field calculations from the reflector code as shown in Figure 11 agree very well with the measured results. The input data for the far field and near field pattern calculations are given in Tables 3 and 4, respectively.

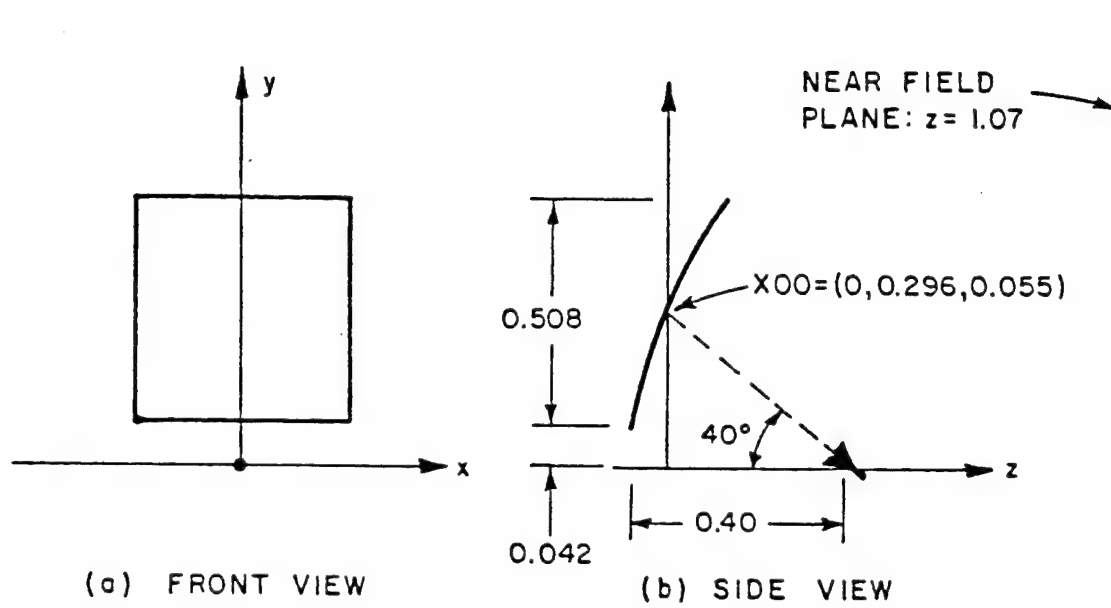


Figure 5. Square reflector of Reference [14]. Dimensions in meters.

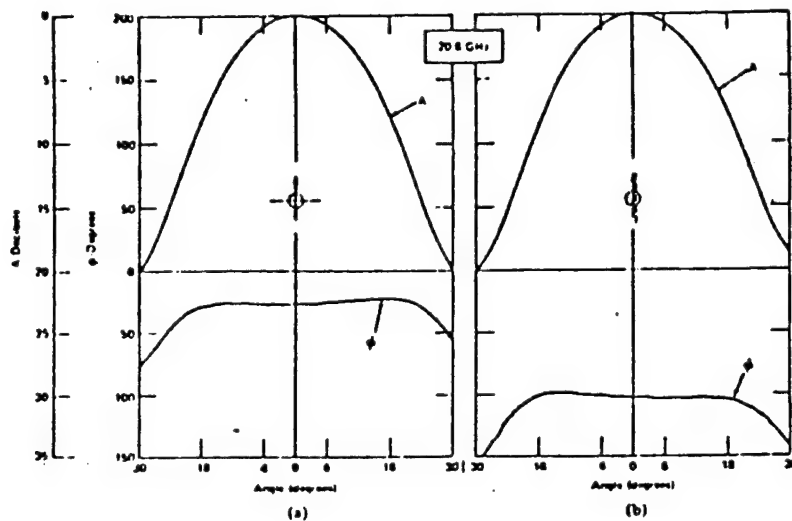


Figure 6. Measured patterns of corrugated horn feed for square reflector [14].

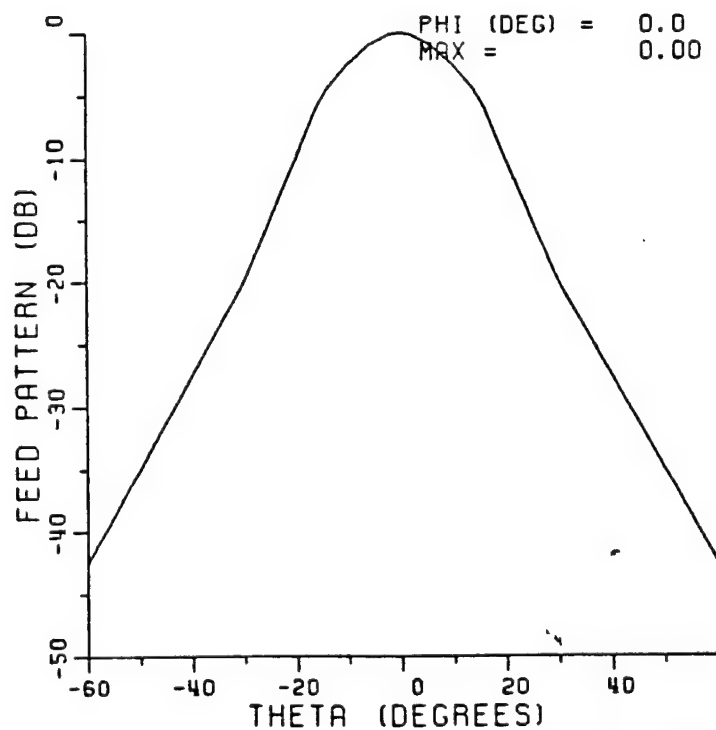


Figure 7. Linear feed pattern input for square reflector.

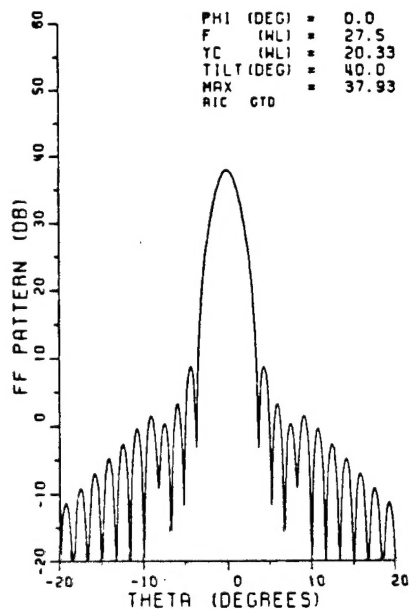


Figure 8a. Far field pattern of Example B computed by OSU Reflector Antenna Code. PHI=0.0 degrees.

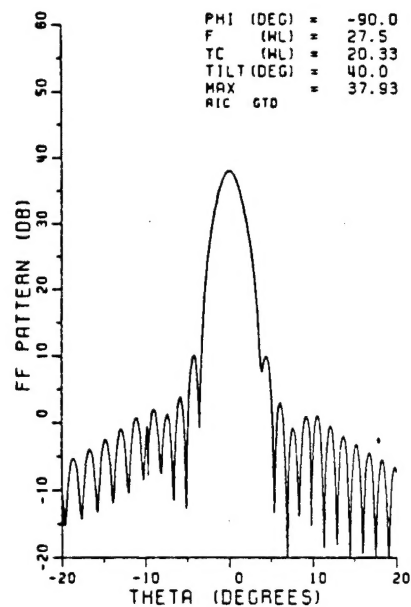


Figure 8b. Far field pattern of Example B computed by NEC Reflector Antenna Code. PHI=-90.0 degrees.

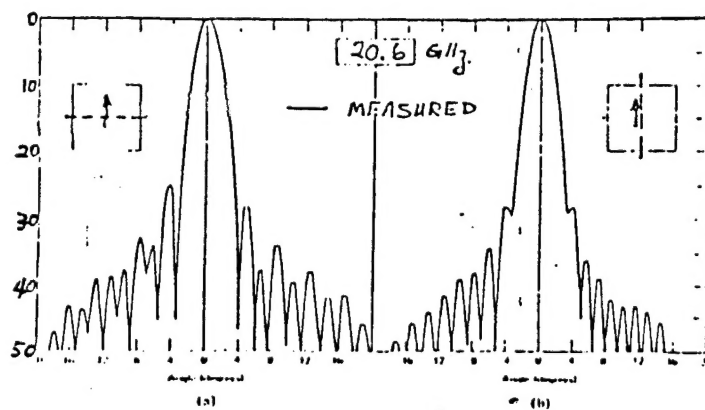


Figure 9. Far field patterns derived from near field measurements.

TABLE 3

INPUT DATA FOR THE FAR FIELD PATTERN CALCULATION OF EXAMPLE B

```

CM:      ***** SQ20L.DAT *****
CM: EXAMPLE OF OFFSET SQUARE REFLECTOR
CE:      FAR-FIELD
DG:
1
1      0.4      0.02      0.02      0.  4
-0.254      0.042
  0.254      0.042
  0.254      0.55
-0.254      0.55
TO:
F      30.  1.
F      0      0      0      0
F      F      F      F      0
T      T      F      0.8
T      F      F      F      T      F      0.  0.
T      T      0.  0.
TL:
40.      0.296
FD:
0      F
0.      0.00816      -0.00967
T      0      T      1      0.  0.  F
1      0.
12
0.      0.00      -25.      -300.00      0.
1.      -0.05      -25.      -300.00      0.
2.      -0.10      -25.      -300.00      0.
3.      -0.40      -25.      -300.00      0.
6.      -1.00      -25.      -300.00      0.
10.     -2.50      -25.      -300.00      0.
15.     -5.00      -25.      -300.00      0.
18.     -8.00      -30.      -300.00      0.
25.     -15.00     -50.      -300.00      0.
30.     -20.00     -75.      -300.00      0.
90.     -65.00    -120.      -300.00      0.
180.    -100.00   -180.      -300.00      0.
FQ:
1      20.6
PZ:
2
0.      -90.
-20.     20.      0.1
F
PP:
1
1      1
1      2
PF:
1
0.
-60.     60.      2.
1
2
XQ:

```

TABLE 4

INPUT DATA FOR THE NEAR FIELD PATTERN CALCULATION OF EXAMPLE B

```

CM:          ***** SQ20N.DAT *****
CM: EXAMPLE OF OFFSET SQUARE REFLECTOR
CE:          NEAR-FIELD
DG:
1
1 0.4 0.01 0.01 0. 4
-0.254 0.042
0.254 0.042
0.254 0.55
-0.254 0.55
FD:
0 T
T 0 T 1 0. 0. F
1 0.
12
0. 0.00 -25. -300. 0.
1. -0.05 -25. -300. 0.
2. -0.10 -25. -300. 0.
3. -0.40 -25. -300. 0.
6. -1.00 -25. -300. 0.
10. -2.50 -25. -300. 0.
15. -5.00 -25. -300. 0.
18. -8.00 -30. -300. 0.
25. -15.00 -50. -300. 0.
30. -20.00 -75. -300. 0.
90. -65.00 -120. -300. 0.
180. -100.00 -180. -300. 0.
TL:
40. 0.296
FQ:
1 20.6
NF:
0. 0.296 0.055
T
F
0.
PZ:
1
1.07
-0.4 0.4 0.01
F
PP:
1
1 1
1 2
XQ:
NF:
0. 0.296 0.055
T
F
90.
PZ:
1
1.07
-0.4 0.4 0.01
F
PP:
1
1 1
1 2
XQ:

```

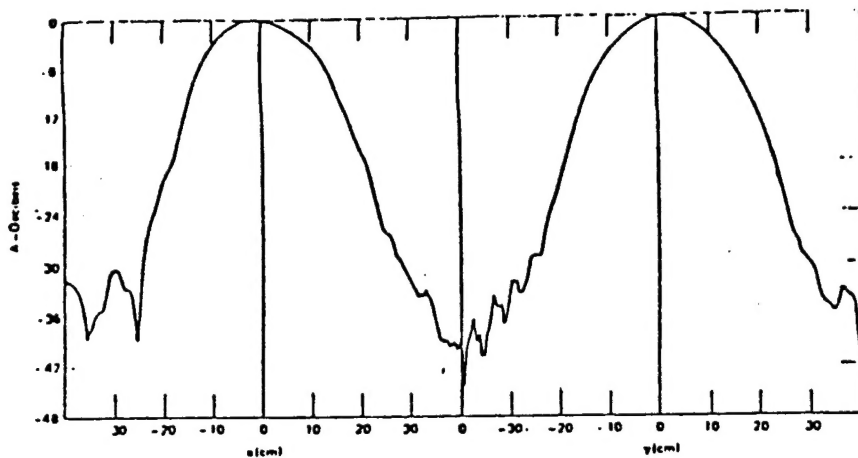


Figure 10. Measured near field of square reflector. Frequency=20.6 GHz, z=1.07 meters.

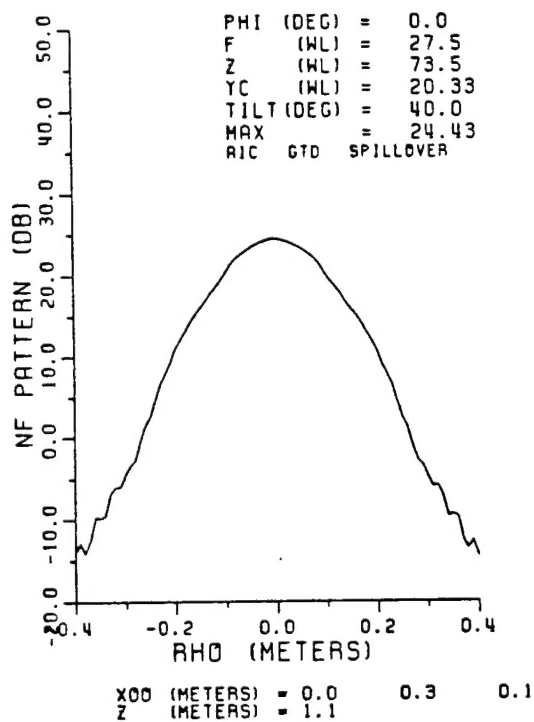


Figure 11a. Near field pattern of Example 4 computed by NEC Reflector Antenna Code. PHI=0.0 degrees.

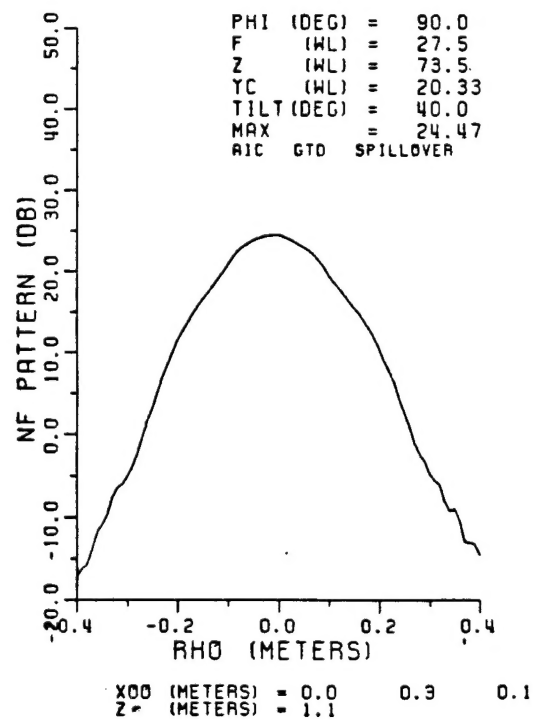


Figure 11b. Near field pattern of Example 4 computed by NEC Reflector Antenna Code. PHI=90.0 degrees.